ICARO

SIAD MACCHINE IMPIANTI

bioplusLNG

OGE

LNG liquefaction plant

HAZOP and SIL Allocation Report

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INTRODUCTION

SIAD Macchine Impianti S.p.A. (the CLIENT) has been awarded by OGE (the COMPANY) for engineering services and provision of new LNG liquefaction plant to be located in Renzenhof (Germany). Within this framework, the CLIENT requested ICARO to provide support to carry out:

- HAZOP (Hazard and Operability) study;
- SIL Allocation.

HAZOP study and SIL Allocation were led by ICARO's senior consultant company, with the participation of SIAD and OGE technicians, also involving a TÜV representative, according to German regulations.

HAZOP and SIL allocation workshops ("sessions") have been held as reported here below:

- From **27th to 31st March 2023** in SIAD premises in Bergamo (Italy),
- From **3rd to 6th April 2023** in OGE premises in Essen (Germany),
- On **17th April 2023** via teleconference.

Present document shows the results of the HAZOP study and SIL Allocation.

HAZOP study allowed to analyse a total number of **26 nodes** and suggest a total number of **67 actions**.
SIL study allowed to analyse a total number of **46 SIFs** and suggest a total number of **10 actions**.
According to the final global results of this study, have been identified:

- A number of **17 SIFs not SIL rated**;
- A number of **25 SIFs rated SIL1**;
- A number of **4 SIFs rated SIL2**.

1 PROJECT OVERVIEW

The project consists into design and provision of new LNG liquefaction plant to be located in Renzenhof (Germany).

Plant is composed of following units:

- natural gas fiscal metering station;
- mercury removal unit;
- CO2 absorption unit;
- amine stripping unit;
- MDEA solvent addition and removal unit;
- natural gas precooling and drying unit;
- liquefaction unit;
- LNG storage;
- LNG truck loading bay.

1.1 HAZOP and SIL allocation scope of work

HAZOP Review will involve equipment and systems under CLIENT's scope of work (main process).

The following systems have not been included in the scope of work of the present HAZOP analysis.

- Packages provide by third-party vendors: steam generation section, cooling water circuit, chillers, demi water package, thermal oxidizer, instrument air package, LIN storage tanks, hot flare.
- Auxiliaries associated to compressors and other machines.

The above listed items have been analyzed from a HAZOP perspective relatively to the interconnection points (interface approach) with main process units and the mutual interactions between the systems were reviewed.

For what concern SIL allocation, only SIFs addressed to prevent scenario with potential impact on personnel safety and/or environment (according to HAZOP outcomes) have been reviewed.

2 DEFINITIONS AND ACRONYMS

2.1 Definitions

Basic Process Control System	The system that responds to input signals from the process and generates output signals to maintain operation of the process in a desired state. The system does not perform functions assessed as SIL 1 or higher.
Beta Factor	The number of Common Mode Failures (of robust Initiators or Final Elements), expressed as a fraction of all possible Failures.
Cause	Reason the occurrence of deviation. Once a deviation can be shown to have a conceivable or realistic cause, then it becomes meaningful. Only single jeopardy together with all relevant effects shall be considered during HAZOP. Deviation is meaningful only if it is physically possible.
Common Mode Failure	A Failure having the potential to affect all duplicated components in a robust configuration by virtue of common or shared characteristics.
Consequences	Results of the deviations.
Dangerous Failure	A Failure that has the potential to place the SIL/IPF in a state in which it will fail to perform its function. Dangerous Failures are usually only safe when the system has to perform a certain action or through testing. Also known as unrevealed failure.
Dangerous Failure Rate	The number of Dangerous Failures per unit time.
Dangerous Failure Robustness	A configuration in which plant integrity is not jeopardised by the Dangerous Failure of a single SIL/IPF component. Also known as unrevealed failure robustness.
Demand	A process or equipment condition or event which requires an IPF / SIF to take action to prevent a Hazardous Situation.
Demand Rate	The frequency at which a Demand occurs, i.e., the number of Demands per unit time.
Design intent	Describes the designer’s desired or specific range of behaviour for elements and characteristics (operating conditions); also identified as “INTENTION”.
Deviation	Departure from design intent. The variations from the intention are systematically identified by applying the "guidewords”
Diagnostic Coverage Factor	The number of Dangerous Failures that diagnostic features are capable of detecting, expressed as a fraction of all possible dangerous failures. (NOTE: Diagnostic features may only be recognised as such if they can trip the process to a safe state or maintain safety by different means.)
Failure	An abnormal condition that may cause a reduction or loss of capability of the IPF to perform its intended function.
Final Element	A device, or combination of devices, that manipulate a process variable or attract the attention of the operator to achieve risk reduction. The Final Element includes output cards or output relays, solenoid valves and cabling. Examples are valves, switchgear (rotating equipment stop circuits) and alarms.
Guidewords	Simple words which are used to qualify each intention in order to guide and stimulate the creative thinking process and discover deviations.
Hazard or Hazardous Situation	A situation with the potential to cause harm, including ill health and injury, damage to property, products or the environment, production losses or increased liabilities.
Hazard Rate	The frequency at which Hazardous Situations occur per unit time. Hazard Rate = Demand rate x Probability of Failure on Demand.
Initiator	A device, or combination of devices, that indicates whether a process or equipment item is operating outside the operating envelope. The Initiator includes input cards and input relays. Examples are manual switches, position switches and measurement systems (including process connections, sensors, transmitters, cabling, trip amplifiers or input cards etc.). In IEC 61508/61511 an Initiator is referred to as a Sensor.

Independent Protection Layer	IPL. Device, system, or action that is capable of preventing a postulated accident sequence from proceeding to a defined, undesirable endpoint. An IPL is (1) independent of the event that initiated the accident sequence and (2) independent of any other IPLs. IPLs are normally identified during layer of protection analyses.
Inspection Time	Time interval between proof tests
Instrumented Protective Function	A function comprising one or more Initiators, a Logic Solver and one or more Final Elements whose purpose is to prevent or mitigate hazardous situations. An IPF is intended to achieve or maintain a safe state for the process, in respect of a specific hazardous event. In IEC 61508/61511 an IPF is referred to as a SIF.
Instrumented Protective System / Safety Instrumented System	The electromechanical, electronic and/or programmable electronic Logic Solver component of the Instrumented Protective Function, complete with input and output equipment. In IEC 61508/61511 an IPS or SIS are referred to as a 'Logic Solver'.
Safeguards	Protection, detection and indication mechanisms for the deviation and relevant consequences, which may be included within the selected part or form a portion of the design intentions of other parts
Logic Solver	The portion of an IPF / SIF that performs the application logic function. The Logic Solver excludes trip amplifiers, input cards and output cards. Examples are electromechanical relays, solid-state/magnetic-core logic and the CPU section of programmable electronic systems.
Mean Time To Restoration	Time interval to repair the failing component. Includes repair time, shipping and managing time
Mitigation	The action of making a consequence less severe or relieving consequences.
Parameters	The team generates possible deviations applying guidewords to various process parameters such as 'Flow', 'Level' and 'Pressure'. The selection of parameters is an important task for each team to devise for each individual system.
Partial Valve Stroke Test	Technique to test a percentage of the possible failure modes of a valve without the need to physically fully close the valve itself.
Probability of Failure on Demand	The probability (dimensionless) of the IPF or SIS failing to respond to a Demand.
Programmable electronics	Electronic component or device forming part of a PES and based on computer technology. The term encompasses both hardware and software and input and output units. (NOTE: This term covers micro-electronic devices based on one or more CPUs together with associated memories, etc. Examples of process sector programmable electronics include: smart sensors; final elements; and programmable electronic logic solvers, such as, programmable controllers, PLCs, DCS, loop controllers.)
Programmable Electronic System	System for control, protection or monitoring based on one or more programmable electronic devices, including all elements of the system such as power supplies, sensors and other input devices, data highways and other communication paths, actuators and other output devices. As an example, an IPS or SIS could be a PES.
Proof Test	A test carried out on IPF components against an approved procedure to confirm that all requirements of the IPF are met.
Proof Test Coverage Factor	The number of Dangerous Failures detected by the Proof Test expressed as a fraction of all possible dangerous failures.
Recommendation	Additional safety measure identified by process team, intended to reduce the risk connected to a specific deviation (also identified as "ACTION").
Risk	The frequency at which a Hazardous Situation occurs multiplied by the consequence of the Hazardous Situation.
Risk Reduction Factor	Is the contribute on an IPL to reduce risk allocated.
Safe Failure	A Failure whose occurrence does not have the potential to place an IPF in a dangerous state. Also known as revealed failure.
Safe Failure Rate	The number of Safe Failures per unit time.

Safe Failure Fraction	The safe failure fraction (SFF) is the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault.
Safety Integrity Level	Dangerous failure class 1, 2, 3 or 4 derived from the consequences of failure on demand and the frequency of demand. The definition in IEC 61511: discrete level (one out of four) for specifying the safety integrity requirements of the IPF / SIF to be allocated to the SIS (trip systems). Safety integrity level 4 has the highest level of safety integrity; safety integrity level 1 has the lowest.
Trip	An Instrumented Protective Function action to bring the Final Element to a safe state.
Undetected Failure	A failure that is not detected by internal diagnostics
Validation	Confirmation that the system under consideration fully meets the integrity requirements set forth in the associated IPF Requirements Specification.
Verification	Demonstration for a particular life-cycle phase that all deliverables (documents, software, hardware) meet the objectives set for that phase.

2.2 Acronyms

BOG	Boil-Off Gas
BPCS	Basic Process Control System
C&E	Cause and Effects Diagram
DCS	Distributed Control System
ESD	Emergency Shut Down
ESDV	Emergency Shut Down Valve
F&G	Fire and Gas
HAZOP	Hazard and Operability study
HC(s)	Hidrocarbon(s)
HFT	Hardware Fault Tolerance
IE	Initiating Event
IEC	International Electrotechnical Commission
IGV	Inlet guide vane
IPL	Independent Protection Layer
IPF	Instrumented Protective Function
IPS	Instrumented Protective System
LIN	Liquefied Nitrogen
LNG	Liquefied Natural Gas
MDEA	Methyl diethanolamine
MTTR	Mean Time To Restoration
NG	Natural Gas
P&ID	Piping and Instrumentation Diagram
PLC	Programmable Logic Controller
PFD	Process Flow Diagram
PFDavg	Probability of Failure on Demand (average)
PSV	Pressure Safety Valve
SDV	Shut Down Valve
SIF	Safety Instrumented Function
SIL	Safety integrity Level
SIS	Safety Instrumented System

3 REFERENCES

3.1 Standards and guidelines

- IEC-61882 “Hazard and operability studies (HAZOP studies) – Application guide, 2016.
- "HAZOP and multistage hazard study", Institution of Chemical Engineers, 1999.
- "Guidelines for Hazard Evaluation Procedures", 2nd Edition, CCPS and AIChE, 1992.
- "A Guide to Hazard and Operability Studies", Chemical Industries Association, 1990.
- IEC 61508:2010 Part 1÷7 “Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems”;
- IEC 61511:2016 Part 1÷3 “Functional safety – Safety Instrumented Systems for the Process Industry Sector.

3.2 Project documentations

- C&E Matrix: 140REZH690010001PFS00101-0C;
- PFD: I20784 Sh 3 – 21;
- P&IDs:
    - 2220698-0C-10-001 sh 2 - 5
    - I20784 Sh 10 - Natural gas inlet
    - I20784 Sh 11 - NG reduction station for steam boiler
    - I20784 Sh 15 - Natural gas treatment and dryer
    - I20784 Sh 16 - Steam condensation and condensate subcooling
    - I20784 Sh 20 - Liquefier cold box LNG
    - I20784 Sh 22 - Liquefier cold box LNG
    - I20784 Sh 23 – Liquefier cold box LNG
    - I20784 Sh 25 – Nitrogen recycle compressor
    - I20784 Sh 26 – Nitrogen booster
    - I20784 Sh 27 - Nitrogen turbine
    - I20784 Sh 30 – LNG storage
    - I20784 Sh 31 – LNG storage
    - I20784 Sh 32 – LNG truck loading pump
    - I20784 Sh 33 – LNG truck loading pump
    - I20784 Sh 34 - Truck loading bay
    - I20784 Sh 35 - Truck loading bay
    - I20784 Sh 36 - NG regeneration cooler
    - I20784 Sh 37 - NG regeneration heater
    - I20784 Sh 37A - NG regeneration compressor
    - I20784 Sh 37B - NG regeneration compressor
    - I20784 Sh 38 – HC heater
    - I20784 Sh 38A – BOG compressor

- I20784 Sh 38B - BOG compressor
- I20784 Sh 39A - Cold flare
- I20784 Sh 39B – Hot flare
- I20784 Sh 40 - Liquid nitrogen storage
- I20784 Sh 41 - Liquid nitrogen storage
- I20784 Sh 42 - Nitrogen distribution system
- I20784 Sh 43 - Instrument air distribution system
- I20784 Sh 50 - Steam boiler
- I20784 Sh 51 - Chiller
- I20784 Sh 60 - Instrument air package
- I20784 Sh 65 - Cooling water system
- I20784 Sh 66 - Cooling water system
- I20784 Sh 67 - Cooling water system
- I20784 Sh 68 - Demi water package
- I20784 Sh 70 - Thermal oxidizer
- I20784 Sh 74 - Analysis pumps
- I20784 Sh 75 - Analysis room
- I20784 Sh 80 - Motors control typical
- I20784 Sh 81 - Heaters control typical
- I20784 Sh 82 - ESD valves typical

4 HAZOP AND SIL METHODOLOGY

The procedures that define modalities and methodologies to be followed in developing the Hazard and Operability - HAZOP – study and SIL allocation are included in **Attachment 7**.

5 HAZOP NODES

An overall number of **26 nodes** has been identified for HAZOP purposes.

List of reference nodes is reported in the following table:

N	Nodes	Drawings
00	General issues	-
01A	Fiscal metering station	I20784 Sh 10
01B	Natural gas supply, preheating, HG removal and absorption	2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
02	Natural gas supply to steam generator	I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
03	Flash vessel	2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
04	NG stream to dryers and condensate separator	2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
05	MDEA Storage tank and dosing	2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
06	MDEA stripping column	2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
07	MDEA blowdown tank	2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
08	Antifoam dosing package	2220698-0C-10-001 Sh 3
09	Natural gas precooling, drying and liquefaction	2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
10	Natural gas dryers regeneration loop	2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
11	LNG separator	I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
12	LNG storage tank including BOG loop	I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
13	LNG tank and truck loading system	I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
14	Heavy HCs KO drum	I20784 Sh 70
15	LNG drain KO drum and cold flare	I20784 Sh 39A
20	Cooling water circuit	I20784 Sh 50; I20784 Sh 51; I20784 Sh 65; I20784 Sh 66; I20784 Sh 67; I20784 Sh 68
21	Steam generation	I20784 Sh 10; I20784 Sh 15; I20784 Sh 37; I20784 Sh 38; I20784 Sh 50
22	Condensate collection	I20784 Sh 10; I20784 Sh 16; I20784 Sh 37; I20784 Sh 38; I20784 Sh 50
23	Chilled water circuit	I20784 Sh 15; I20784 Sh 25; I20784 Sh 36; I20784 Sh 51
24	Demi water package	I20784 Sh 68

N	Nodes	Drawings
25	Instrument air production	I20784 Sh 42; I20784 Sh 43; I20784 Sh 60
30	Liquid Nitrogen supply to cold box and nitrogen recycle compressor	I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
31	LNG subcooler	I20784 Sh 23
32	Liquid nitrogen vaporizers, nitrogen heater and distribution	I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42

Additional information regarding each node, listed above, (e.g. node intention - operating and design conditions, relevant P&IDs, equipment, specific notes, etc.) are reported in HAZOP worksheets (ref. to **Attachment 3**).

The complete set of marked-up P&IDs with the above stated nodes is reported in **Attachment 2**.

6 HAZOP AND SIL TEAM AND VENUES

HAZOP and SIL study working team was composed by technicians of SIAD Macchine Impianti S.p.A. (the CLIENT) and OGE (the COMPANY) and was led by Fabrizio Bucci, a 3rd party qualified specialist not involved in the project development, acted as HAZOP Chairperson/ SIL Facilitator.

HAZOP workshop sessions have been held:

- from **27th to 31st March 2023** in SIAD premises in Bergamo (Italy),
- from **3rd to 6th April 2023** in OGE premises in Essen (Germany),

SIL allocation workshop session has been held:

- on **17th April 2023** via teleconference.

Attendance lists are reported in **Attachment 1**.

7 HAZOP RESULTS

7.1 HAZOP Worksheet

The HAZOP worksheets were shown during the recording with sharing the screen to immediately allow the team to read, comment and, at the end, to agree on the recorded minute.

The HAZOP study was recorded with the software PHA Works. The worksheets registered during the session are enclosed in **Attachment 3**.

These worksheets include:

- Node number, identification, and intention.
- List of the drawings containing the node.
- Parameter / guideword / deviations / consequences / available safeguards.
- Risk ranking.
- Recommendations/actions (when required);
- Recommendation Owner.

7.2 HAZOP Recommendations

During HAZOP an overall number of **67 recommendations** has been suggested and agreed by the team.

HAZOP Recommendation list is reported on **Attachment 4**.

Close-out of the HAZOP recommendation is part of a separate activity and therefore is not included in the present report.

8 SIL ALLOCATION RESULTS

8.1 SIL Worksheet

Starting from HAZOP results, the SIL analysis allowed the team to define the Safety Criteria and Mitigation of hazards which can lead to a significant safety or environmental consequences.

Scenario with economic consequences have not been included in this SIL Allocation study.

A total number of **46 SIFs** have been identified and analyzed, with following results:

- A number of **17 SIFs not SIL rated**;
- A number of **25 SIFs rated SIL1**;
- A number of **4 SIFs rated SIL2**.

The SIF List and corresponding SIL rating are listed in **Attachment 6**.

The analysis has been recorder in dedicated worksheet specifically defined for the application of SIL Allocation Procedure according to ICARO standards. SIL Worksheets are reported in **Attachment 5.**

In the worksheet for each SIF are indicated:

- SIF identification (initiator, logic solver, final elements);
- Identification of initiating events;
- Scenario description;
- Operators occupancy;
- Probability of avoiding the hazardous situation
- Available IPL;
- Scenario requiring SIF demand rate;
- SIL requirement;
- SIL selected;
- Recommendations if required.

8.2 SIL Allocation Recommendations

During the SIL analysis an overall number of **10 recommendations** has been suggested and agreed by the team; those recommendation are listed in the following table:

SIF N	SIF	Recommendation Ref.	Recommendation
10	PAHH (interlock to shut down HV-138 in case of back flow due to both P2005A/B not running)	1	Effectiveness of PSV-271 in case of back flow from TW1002 to TW2008 shall be verified considering presence of 2 check valves dissimilar type (reduced required discharge capacity according to reference standard API 521, chapter 4.4.9.3.3). If PSV is adequate, required SIL ca be derated by 1 level ensuring periodical testing on check valves. For this purpose it is suggested to install second dissimilar check valve on dedicated discharge line of each P2005A/B
15	TAHH-466	2	Provide an additional independent temperature transmitter at H4006 outlet with high temperature alarm
18	TAHH-535	3	Provide an additional independent temperature transmitter on NG line upstream EW5000 including high temperature alarm
27	PAHH-1960A	4	Provide an independent function (additional pressure transmitter) to trip P19000 and to close HV-1902A in case of high pressure (set point lower than PAHH-1960A)
28	PALL-1960A	5	Intervention of PALL-1961A shall also close HV-1957A and HV-1958A
29	TALL-914	6	Provide an additional independent temperature transmitter at EW9000 outlet (road tanker BOG line) with low temperature alarm
33	TALL-913	7	Provide an additional independent temperature transmitter at EW9000 outlet (storage tank BOG line) with low temperature alarm
34	TALL-915	8	Provide an additional independent temperature transmitter at EW9000 outlet (NG line) with low temperature alarm
43	PAHH-1640	9	Ensure adequate set point for PAHH-1640 to prevent overpressurization on upstream S2011 (DP=2 barg)
45	TAHH (overheating of WB41/WB42 downstream piping)	10	Investigate availability of other IPL to prevent piping overheating downstream WB41/WB42

Close-out of the SIL recommendation is part of a separate activity and therefore is not included in the present report.

ATTACHMENT 1

Attendance List

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 27/03/2023 **SESSION No.** #1

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	[signature]
DEBORA D'OSTILIO	ICARO	SCRIBE	[signature]
GENNARO FORMISANO	SIAD	PM	[signature]
Mariano Cometti	SIAD MI	INSTRUMENT	[signature]
PAOLO ANTONELLI	SIAD MI	PROJECT ENGINEERING	[signature]
FEDERICO SORU	SIAD TI	INSTRUMENT	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
CHRISTIAN TIETZE	OGE	Engineering Group	[signature]
Christian Ludwiczak	OGE	Project Manager	[signature]
Sebastian Hänle	TÜV SÜD	Plant Safety	[signature]
PIERLUIGI GRITTI	SIAD MI	SENIOR TECH. MGR	[signature]
DANIELE SANTUS	TPI	PROCESS ENG.	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 28/03/2023 **SESSION No.** #2

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	CHAIRPERSON	[signature]
DEBORA D'OTTAVIO	ICARO	SCRIBE	[signature]
DANIELE SANTUS	TPI	PROCESS	[signature]
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FEDERICO SORU	SIAD M.	INSTRUMENTATION	[signature]
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Christian Ludwiczak	OGE	Project Manager	[signature]
Sebastian Hänle	TÜV SÜD	Plant Safety	[signature]
Christian Tietze	OGE	Engineering Manager	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
PAOLO ANTONELLI	SIAD MI	PROJECT ENGIN.	[signature]
Klaus Thomas	OGE	Process Control	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 29/03/2023 **SESSION No.** #3

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	CHAIRPERSON	[signature]
DEBORA D'OSTILIO	ICARO	SCRIBE	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
Christian Tietze	OGE	Eng. Manag.-t	[signature]
Christian Ludowicz[illegible]	OGE	Project Management	[signature]
Sebastian Hönle	TÜV SÜD	Plant Safety	[signature]
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ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 30/03/2023 **SESSION No.** # 4

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	
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PIERLUIGI GRITTI	SIAD MI	SENIOR TECH. ADVISOR	

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 31/03/2023 SESSION No. #5

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	[signature]
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GENNARO FORMISANO	SIAD MI	PM	[signature]
Klaus Thomas	OGE	Process Control	[signature]
DANIELE ARIMONDI	SIAD MI	SAFETY ENGINEER AUT. COORDINATOR	[signature]
PAOLO ANTONELLI	SIAD MI	PE	[signature]
FEDERICO SORU	SIAD MI	INSTRUMENTATION	[signature]
PIERLUIGI GRITTI	SIAD MI	SENIOR TECHN. ADVISER	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 31.04.2023 **SESSION No.** #6

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	[signature]
DEBORA D'OSTILIO	ICARO	SCRIBE	[signature]
Christian Ludwiczak	OGE	Project Manager	[signature]
Sebastian Hönle	TÜV SÜD	Plant Safety	[signature]
Klaus Thomas	OGE	Process Control	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
GENNARO FORZISANO	SIAD MI	PR	[signature]
DANIELE ARIMONDI	SIAD MI	FUNCT. SAFETY ENGINEER AUT. COORDINATOR	[signature]
PAOLO ANTONELLI	SIAD MI	PE	[signature]
Mariano Cumetti	SIAD MI	FS / Instrument Engineer	[signature]
FEDERICO SORU	SIAD MI	INSTRUMENTATION	[signature]
Christian Tietze	OGE	Eng. Ma.	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 4/04/2023 **SESSION No.** #7

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	[signature]
Christian Ludwiczak	OGE	Project Manager	[signature]
Christian Tietze	OGE	Eng. Mgr.	[signature]
Christoph Hopp	OGE	Franconia Operations Area	[signature]
Klaus Thomas	OGE	Process Control	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
Sebastian Häule	TÜV SÜD	Plant Safety	[signature]
GENNARO FORMISANO	SIAD MI	Jeun PM	[signature]
ARIMONDI DANIELE	SIAD MI	FS ENGINEER (TUV) AUTOMATION COORD.	[signature]
PAOLO ANTONELLI	SIAD MI	PE	[signature]
FEDERICO SORU	INSTRUMENTATION	SIAD MI	[signature]
Mariano Cometti	SIAD MI	FS Engineer Instrument	[signature]
DEBORA D'OSTILIO	ICARO	SCRIBE	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	SIAD / BIOPLUS LNG GmbH	
	Plant Site:	Renzenhof (Germany)	
	Project:	LNG Liquefaction Plant	
	ICARO Job:	23123I	

DATE: 5/04/2023 **SESSION No.** #8

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	CHAIRPERSON	[signature]
DEBORA D'OSTILIO	ICARO	SCRIBE	[signature]
Christian Tietze	OGE	Eng. Mgt.	[signature]
Christoph Hopp	OGE	Fernleitung Operations Area	[signature]
Klaus Thomas	OGE	Process Control	[signature]
CHRISTIAN SCHMITT	OGE	PROCESS	[signature]
Sebastian Klünle	TÜV SÜD	Plant Safety	[signature]
GENNARO FORTUNATO	SIAD MI	PM	[signature]
DANIELE ARIMONDI	SIAD MI	FS ENGINEER AUT. COORDINATOR	[signature]
PAOLO ANTONELLI	SIAD MI	PE	[signature]
FEDERICO SORU	SIAD MI	INSTRUMENT	[signature]
Mariano Cumetti	SIAD MI	FS Engineer Instrument	[signature]
Christian Ludwiczek	OGE	Project Manager	[signature]

ICARO	HAZOP & SIL STUDY ATTENDANCE LIST		SIAD MACCHINE IMPIANTI / bioplusLNG / OGE
	Company:	**SIAD / BIOPLUS LNG GmbH**	
	Plant Site:	**Renzenhof (Germany)**	
	Project:	**LNG Liquefaction Plant**	
	ICARO Job:	**23123I**	

DATE: 17/04/2023 **SESSION No. #9**

Name:	Company:	Expertise:	Signature:
FABRIZIO BUCCI	ICARO	Chairperson	Via teleconference
DEBORA D'OSTILIO	ICARO	Scribe	Via teleconference
GENNARO FORMISANO	SIAD MI	PM	Via teleconference
PAOLO ANTONELLI	SIAD MI	PE	Via teleconference
FEDERICO SORU	SIAD MI	Instrument	Via teleconference
MARIANO CUMETTI	SIAD MI	FS engineer instrument	Via teleconference
DANIELE ARIMONDI	SIAD MI	FS engineer aut. coordinator	Via teleconference
DANIELE SANTUS	TPI	Process	Via teleconference
KLAUS THOMAS	OGE	Process Control	Via teleconference
CHRISTIAN LUDWICZAK	OGE	PM	Via teleconference
CHRISTIAN SCHMITT	OGE	Process	Via teleconference
CHRISTIAN TIETZE	OGE	Eng Manager	Via teleconference
SEBASTIAN HOENLE	TÜV SÜD	Plant safety	Via teleconference

ATTACHMENT 2

Master Copy P&IDs

Liefergrenzen:
1 - vorhanden
8 - Rohrleitungstechnik (inkl. Schnittstelle Anbohrung)
12 - Leittechnik

DP-23042	Neubau Bio LNG Renzenhof
Projektnummer OGE	Maßnahmenbezeichnung OGE

Rev. Nr.	Datum	Beschreibung	erstellt	geprüft	freigegeben	Datum	freigegeben
0D	23.03.2023	Allgemeine Überarbeitung	J63390	M21585	C62717	---	---
0C	19.12.2022	Allgemeine Überarbeitung	M68178	C18018	C62953	---	---
0B	29.08.2022	Überarbeitung zur Erstellung Lastenheft	M68178	---	---	---	---
0A	15.02.2022	Projekt Bio LNG	M68178	C63953	---	---	---
05	28.10.2019	PA-16207 Rückbau VD Renzenhof	T61095	S63687	---	---	---
04	11.12.2017	PA-17517 Trennstellen AIS-NIS	M60973	C18433	C18433	---	---

Projekt - Nr.

PLEDOC

Standort: Renzenhof

	Datum	Name
Erst.	29.08.2022	M68178
Gepr.		
Freig.		

Zeichnungsbenennung: R+I Schema Stationspiping

Schutzvermerk ISO 16016 beachten	Blattgr.	Maßstab	F-Tech	Standortkurzname	A-Art	Anl-Nr	A-Teil	D-Art	Lfd.-Nr	Blatt	Änd
	A0	/	520	REZH	700	001	000	SRI	001	01-	0D

Urspr.: --- Ers.f.: 350REZH690SRI00108000000000 Ers.d.: ---

520REZH700SRI0010000100001-.DWG

The gas pressure regulator has a set pressure of 43 bar. The setting pressure is adjusted via the pressure connection HOB B40622. If there is a pressure increase in the area behind the gas pressure regulator (e.g. gas pressure regulator leaking), the SBV is triggered at approx. 45.4 bar. Furthermore, two SSVs are installed per control line to limit a pressure increase in the GDRM system in the event of a fault.

"The cutting point for the LNG plant construction is the bolted connection at the PGC."

Node #01A

DP 85
DT 80
MOPu 67,5 ; MOPd 43
MOT 60
Metering an Regulating: DT-10°C - +60°C

LEGEND:

FT = FLOW TRANSMITTER
HOB = BALL VALVE
HON = NEEDLE VALVE
MCV = ELECTRICAL CONTROL VALVE
PDI = PRESSURE DIFFERENCE MANOMETER
PDIT = DIFFERENTIAL PRESSURE TRANSMITTER
PI = PRESSURE INDICATOR MECHANICAL
PT = PRESSURE TRANSMITTER
SBV = SAFETY BLOW-OFF VALVE
SRV= SAFETY CHECK VALVE
SSV = SAFETY SHUT-OFF VALVE
TT = TEMPERATURE TRANSMITTER
U = GAS METER
W = HEAT EXCHANGER

1	vorhanden
2	Lieferant Filter
3	Lieferant Vorwärmer
4	GDRM-Technik Messanlage
5	Lieferant Maschinen-/Verdichtereinheit
6	Lieferant Kühler
7	Lieferant Ausbläser
8	Rohrleitungstechnik
9	Lieferant Druckluftanlage
10	Lieferant Fackelanlage
11	Lieferant Kondensatbehälter
12	Leittechnik
13	Energietechnik (TPEE)
14	Qualitätsmessung
15	TGA
16	Anlagenbau
17	GDRM-Technik Eigengasversorgungsanlage
18	GDRM-Technik Kompaktanlage
19	Fernleitungsbau
20	Demontage
21	Lieferant HSS-Anlage(> 110 KV)
22	Lieferant HS-Anlage (> 36KV)
23	Lieferant MSA/Trafo (<=36KV)
25	Lieferant Frischwasserversorgung
26	Lieferant Löschwassertank
27	Lieferant Löschwasserring
28	Lieferant Kesselanlage
29	Lieferant Nachrichtentechnik
30	Lieferant Sicherheitstechnik
98	Betriebliche Maßnahme
99	Demontage

Rev. Nr.	Datum	Beschreibung	erstellt	geprüft	freigegeben	Datum	freigegeben
0E	19.01.2023	Anpassung an aktuellen Planungsstand	K62341	---	---	---	---
0D	09.12.2022	Allgemeine Überarbeitung	M68178	A63569	---	---	---
0C	25.11.2022	Isoliertrennstelle ergänzt	M68178	A63569	---	---	---
0B	29.08.2022	Überarbeitung zur Erstellung Lastenheft	M68178	C62953	---	---	---
0A	15.02.2022	Ersterstellung	M68178	C62953	---	---	---

Projekt - Nr.

Standort: Renzenhof

	Datum	Name
Erst.	23.01.2023	K62341
Gepr.		
Freig.		

bioplusLNG

OGE

Zeichnungsbenennung: Rohrleitungs- und Instrumentenfließschema Bio LNG-Anlage -GDRM-Anlage-

Schutzvermerk ISO 16016 beachten	Blattgr.	Maßstab	F-Tech	Standortkurzname	A-Art	Anl-Nr	A-Teil	D-Art	Lfd.-Nr	Blatt	Änd
	A0	/	520	REZH	433	004	000	SRI	001	01-	0E

Urspr.: --- Ers.f.: --- Ers.d.: ---

520REZH433004000SRI00101-.DWG

VALVE LEGEND:

- BALL VALVE
- NEEDLE VALVE
- CHECK VALVE
- GLOBE VALVE
- BUTTERFLY VALVE
- SPECTACLE BLIND
- Y STRAINER
- S — PNEUMATIC BALL VALVE (SE)
- S S — FC ESD — PNEUMATIC BALL VALVE (ESD)
- S S — FL — PNEUMATIC BALL VALVE (DE)
- SAFETY VALVE
- S — SOLENOID VALVE
- PRESSURE REGULATOR
- PNEUMATIC GLOBE VALVE
- S — PNEUMATIC GLOBE VALVE WITH SOLENOID BLOCK VALVE
- STEAM TRAP
- SIGHT GLASS
- PLUG

FC = FAIL CLOSED
FO = FAIL OPEN
FL = FAIL LOCK
LC= LOCKED CLOSE
LO= LOCKED OPEN

INSTRUMENT LEGEND:

- PI — PRESSURE GAUGE
- TI — THERMOMETER
- FI — FLOWMETER
- FIT — FLOW TRANSMITTER ANALOGIC 4-20 mA
- M — MOTOR
- VFD — VARIABLE FREQUENCY DRIVER
- PI / PT — PRESSURE TRANSMITTER ANALOGIC 4-20 mA (PIC= CONTROLLER)
- TI / TT — TEMPERATURE TRANSMITTER ANALOGIC 4-20 mA (TIC= CONTROLLER)
- LI / LT — LEVEL TRANSMITTER ANALOGIC 4-20 mA (LIC= CONTROLLER)
- FI / FE+FT — FLOW TRANSMITTER ANALOGIC 4-20 mA (FIC= CONTROLLER)
- PDI / PDT — DIFFERENTIAL PRESSURE TRANSMITTER ANALOGIC 4-20 mA
- PAH / PSH — PRESSURE SWITCH (HIGH)
- FAL / FSL — FLOW SWITCH (LOW)
- LAL / LAH / LSL / LSH — LEVEL SWITCH (LOW/HIGH)
- LALL / LAHH / LSLL / LSHH — LEVEL SWITCH (LOW LOW/HIGH HIGH)
- ZAL / ZAH / ZSL / ZSH — LIMIT SWITCH
- OPERATOR ACCESSIBLE WITH SAFETY FUNCTION
- OPERATOR ACCESSIBLE WITH CONTROL FUNCTION

NG-201-4"-C18-I

FLUID — NPS — INSULATION — LINE NUMBER — PIPING CLASS

FLUID LIST:
- NG= NATURAL GAS
- N= NITROGEN
- Ra= RICH AMINE
- La= LEAN AMINE
- K= CO2
- CW= COOLING WATER
- BW= DEMI WATER
- LS= STEAM
- LC= CONDENSATE STEAM
- HC= LIQUID HYDROCARBONS
- A= INSTRUMENT AIR
- CD= CONDENSATE
- AF= ANTIFOAM

INSULATION:
- F= COLD INSULATION
- I= HOT INSULATION
  - PERSONNEL PROTECTION
  - HEAT TRACING
- N= NOT PAINTED/ NOT INSULATED
- V= PAINTED

- CONCENTRIC REDUCER
- ECCENTRIC REDUCER
- PIPING SLOPE
- ELECTRICAL HEAT TRACING
- HEAT CONSERVATION / PERSONNEL PROTECTION
- COLD CONSERVATION

Rev. Nr.	Datum	Beschreibung	erstellt	geprüft	freigegeben	Datum	freigegeben
06							
05							
04							
03							
02							
01							
			---			---	

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Projektnummer OGE	Maßnahmenbezeichnung OGE

Projekt - Nr.			Standort / Projektname
DG-001115			LNG LIQUEFACTION PLANT

	Datum	Name
Erst.	13/03/2023	FR
Gepr.	13/03/2023	CA
Freig.	13/03/2023	DS

Zeichnungsbenennung

NG TREATMENT UNIT - PIPING AND INSTRUMENTATION DIAGRAM
NG BEHANDLUNGSEINHEIT - ROHRLEITTUNGEN UND INSTRUMENTIERINGS DIAGRAMM

Schutz-vermerk ISO 16016 beachten	Blattgr.	Maßst. 1/	F-Tech	Standortkurzname	A-Art	Anl-Nr	A-Teil	D-Art	Lfd.-Nr	Blatt	Änd
	A1	___	520	REZH	598	004	003	SRI	001	01+	0C

Urspr.: 2220698-0C-10-001 / EST105704 | Ers.f.: | Ers.d.:


CO2 ABSORPTION UNIT
AU1000
NODE #01B
NODE #03
NODE #04
NODE #06
NOTE 1: CONNECTED TO COLD FLARE HEADER
NOTE 2: GENERAL P&ID, DOCUMENT SIAD M.I. N° I20784
NOTE 3: PSV CONNECTED TO BLOWDOWN MDEA HEADER
NOTE 4: ON/OFF VALVE WITH ADJUSTABLE OPENING
NOTE 5: FLASH VESSEL S1003 ELECTRICALLY TRACED
NOTE 6: ABSORPTION TOWER TW1002 ELECTRICALLY TRACED TO LIQUID LEVEL AT PLANT STOP
NOTE 7: P&ID N° I20784
NOTE 8: MINIMUM DISTANCE FROM HV164 TO R0169 MUST BE 600mm
1.1 RAW NATURAL GAS INLET 4" 600#
1.3 NATURAL GAS TO DRYER 4" 600#
1.4 LEAN AMINE INLET 2" 600#
1.6 AMINE FLASH 1/2" 150#
1.7 TO AMINE BLOWDOWN VESSEL 1" 150#
1.10 RICH AMINE FROM FLASH VESSEL 2" 150#
1.11 AMINE DISCHARGE 1" 600#
1.12 CONDENSATE FROM PRECOOLER 1/2" 150#
1.13 LIQUID HYDROCARBON DISCHARGE 3/4" 150#
1.14 AMINE DISCHARGE 1" 150#
1.17 INSTRUMENT AIR 3/4" 150#
1.18 NITROGEN INLET 1-1/2" 150#
1.19 TO COLD FLARE 3" 150#
1.20 TO HOT FLARE 1/2" 150#
INSTRUMENT AIR SIAD M.I. I20784
NATURAL GAS TO DRYER SIAD M.I. I20784
RAW NATURAL GAS INLET SIAD M.I. I20784
NITROGEN CONNECTION SIAD M.I. I20784
TO COLD FLARE SIAD M.I. I20784
AMINE FLASH TO NG REGENERATION COOLER - SIAD M.I. I20784
CONDENSATE FROM PRECOOLER SIAD M.I. I20784
TO MDEA BLOWDOWN TANK SIAD M.I. I20784
LIQUID HYDROCARBON DISCHARGE SIAD M.I. I20784
LEAN AMINE FROM HW2004 SIAD M.I. I20784
AMINE DISCHARGE SIAD M.I. I20784
TO HOT FLARE SIAD M.I. I20784
RICH AMINE TO HW2007 SIAD M.I. I20784
S1001 GUARD SEPARATOR
TW1002 ABSORPTION COLUMN
F1005 MERCURY TRAP
F1006 DUST FILTER
S1003 FLASH VESSEL NOTE 5
FROM PT439
FROM PT440
FROM PT441
FROM PT600 NOTE 7
SIAD M.I. T.P.I.
LIMIT OF SUPPLY
CLIENTE client BIOPLUS LNG
STABILIMENTO factory RENZENHOF (GERMANY)
OGGETTO object NATURAL GAS TREATMENT CO2 REMOVAL AND DRYING CO2 ABSORPTION UNIT
0C REVISIONE - Revision 13/03/2023 FR CA DS
0B REVISIONE - Revision 22/02/2023 FR CA DS
0A PRIMA EMISSIONE - First Issue 18/01/2023 FR CA DS
COMMESSA job G22C20698
DATE date 18/01/2023
ESEG. prep'd FR
FG. sh. 2 DI of 5
FORMAT size A1
TECNO PROJECT INDUSTRIALE
PLANTS AND TECHNOLOGY FOR THE INDUSTRIAL GASES
CURNO - BERGAMO - ITALY
DISEGNO N° drawing n° 2220698-0C-10-001
REV. 0C

AMINE STRIPPING UNIT – SU2000

NOTE 2: GENERAL P&ID, DOCUMENT SIAD M.I. N° I20784

NOTE 4: PSV CONNECTED TO MDEA BLOWDOWN TANK

NOTE 5: CARBON GUARD BED ELECTRICALLY TRACED

NOTE 6: STRIPPING TOWER TW2008 ELECTRICALLY TRACED TO LIQUID LEVEL AT PLANT STOP

NOTE 7: CONDENSATE SEPARATOR S2011 ELECTRICALLY TRACED

NOTE 8: WEEP HOLE AT LOWEST POINT DOWNSTREAM OF PSV271

NOTE 9: BELT DRUM HEATER

2.1	LEAN AMINE	2" 600#
2.2	TO COMBUSTOR	2" 150#
2.3	RICH AMINE FROM FLASH	2" 150#
2.4	CONDENSATE FROM C5500	1/2" 150#
2.5	MDEA LOADING	1" 150#
2.6	INSTRUMENT AIR	1/2" 150#
2.7	LP STEAM	3" 150#
2.8	LP STEAM CONDENSATE	2" 150#
2.10	DEMI WATER INLET	1/2" 150#
2.11	TO MDEA BLOWDOWN TANK	1" 150#
2.12	COOLING WATER OUTLET	4" 150#
2.13	COOLING WATER INLET	4" 150#
2.14	NITROGEN INLET	1/2" 150#
2.15	CONDENSATE FROM ST9000	1/2" 150#
2.16	TO MDEA BLOWDOWN TANK	1" 150#

SIAD M.I. | T.P.I.

LIMIT OF SUPPLY

REV. rev.	DESCRIZIONE description	DATA date	ESEG. prep'd	CONTR. chk'd	APPR. appr'd
0C	REVISIONE – Revision	13/03/2023	FR	CA	DS
0B	REVISIONE – Revision	22/02/2023	FR	CA	DS
0A	PRIMA EMISSIONE – First Issue	18/01/2023	FR	CA	DS

CLIENTE client: BIOPLUS LNG

STABILIMENTO factory: RENZENHOF (GERMANY)

OGGETTO object: NATURAL GAS TREATMENT CO2 REMOVAL AND DRYING AMINE STRIPPING UNIT

COMMESSA job: G22C20698

COD. ART. article code:

DATE date: 18/01/2023

SCALA scale:

FG. sh. 3 DI of 5

FORMAT size: A1

ESEG. prep'd: FR

MASSA (Kg) poids:

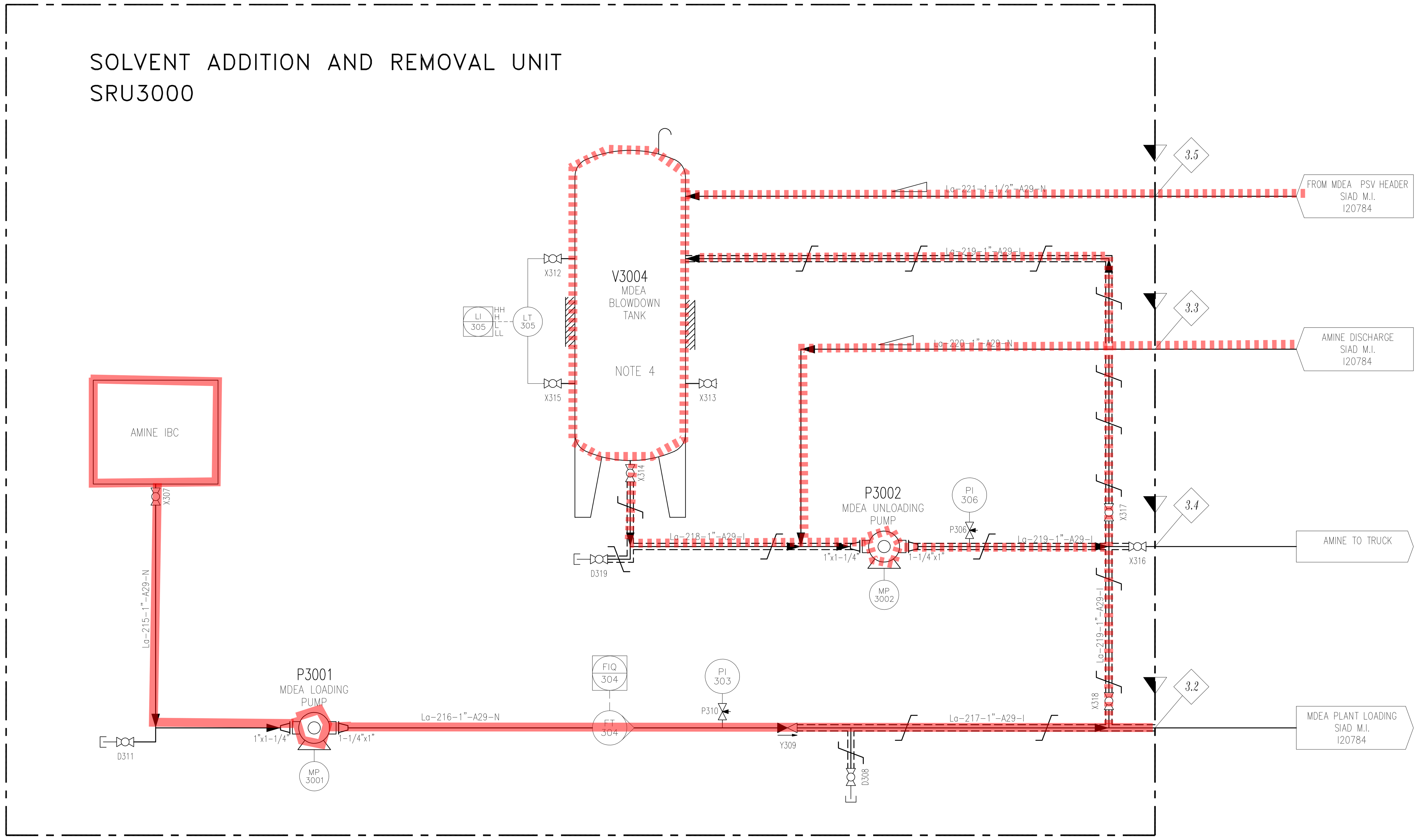
DISEGNO N° drawing n°: 2220698-0C-10-001

REV.: 0C

TECNO PROJECT INDUSTRIALE
PLANTS AND TECHNOLOGY FOR THE INDUSTRIAL GASES
CURNO – BERGAMO – ITALY

NODE #05

NODE #07



3.2	MDEA PLANT LOADING	1" 150#
3.3	AMINE DISCHARGE	1" 150#
3.4	AMINE TO TRUCK	1" 150#
3.5	FROM MDEA PSV HEADER	1-1/2" 150#

NOTE 1: GENERAL P&ID, DOCUMENT SIAD M.I. N° I20784

NOTE 4: MDEA BLOWDOWN TANK V3004 ELECTRICALLY TRACED

SIAD M.I. | T.P.I.

LIMIT OF SUPPLY

CLIENTE client	BIOPLUS LNG	0C	REVISIONE - Revision	13/03/2023	FR	CA	DS
		0B	REVISIONE - Revision	22/02/2023	FR	CA	DS
STABILIMENTO factory	RENZENHOF (GERMANY)	0A	PRIMA EMISSIONE - First Issue	18/01/2023	FR	CA	DS
		REV. rev.	DESCRIZIONE description	DATA date	ESEG. prep'd	CONTR. chk'd	APPR. appr'd

OGGETTO object: NATURAL GAS TREATMENT
CO2 REMOVAL AND DRYING
SOLVENT ADDITION AND REMOVAL UNIT

COMMESSA job: G22C20698 | COD. ART. article code:

DATE date: 18/01/2023 | SCALA scale: | FG. sh. 4 | FORMAT size: A1

ESEG. prep'd: FR | MASSA (Kg) poids: | DI of 5

TECNO PROJECT INDUSTRIALE
PLANTS AND TECHNOLOGY FOR THE INDUSTRIAL GASES
CURNO - BERGAMO - ITALY

DISEGNO N° drawing n°: 2220698-0C-10-001 | REV. 0C


NATURAL GAS PRECOOLING AND DRYING UNIT
DU4000
NODE #04
NODE #09
NODE #10
4.1 WET NATURAL GAS INLET 4" 600#
4.2 CHILLED WATER OUTLET 3" 150#
4.3 CHILLED WATER INLET 3" 150#
4.4 CONDENSATE OUTLET 1/2" 150#
4.5 REGENERATION GAS 3" 600#
4.6 DEPRESSURIZZATION GAS 1" 600#
4.7 NITROGEN INLET 1/2" 150#
4.8 TO COLD FLARE 3" 150#
4.9 NATURAL GAS TO LIQUEFACTION 4" 600#
4.10 DRAIN 1/2" 150#
4.11 INSTRUMENT AIR 1" 150#
4.12 TO HOT FLARE 1/2" 150#
TO COLD FLARE SIAD M.I. 120784
NITROGEN CONNECTION SIAD M.I. 120784
INSTRUMENT AIR SIAD M.I. 120784
WET NATURAL GAS SIAD M.I. 120784
CHILLED WATER OUTLET SIAD M.I. 120784
CHILLED WATER INLET SIAD M.I. 120784
CONDENSATE TO FLASH VESSEL SIAD M.I. 120784
TO HOT FLARE SIAD M.I. 120784
REGENERATION GAS SIAD M.I. 120784
DEPRESSURIZATION GAS SIAD M.I. 120784
NATURAL GAS TO LIQUEFACTION SIAD M.I. 120784
H4006 REGENERATION HEATER
V4003 DRYER VESSEL #1
V4004 DRYER VESSEL #2
V4005 DRYER VESSEL #3
F4005 DUST FILTER
HW4001 PRECOOLER
ST4001 PRECOOLER CONDENSATE SEPARATOR
HW4002 DRYER AFTERCOOLER
TO PDY 122A
TO PDY 122B
TO PDY 122C
PERSONNEL PROTECTION
NOTE 1: PSV CONNECTED TO COLD FLARE HEADER
NOTE 2: GENERAL P&ID, DOCUMENT SIAD M.I. N° 120784
NOTE 3: SLOW-CLOSING VALVES KV401, KV424, KV446 KV447, KV430, KV448, KV432, KV431, KV498, KV497, KV496, KV495, KV494, KV493
NOTE 4: VALVES HV455, HV464 CONNECTED TO COLD FLARE HEADER
NOTE 5: VALVES V458, V467 CONNECTED TO HOT FLARE HEADER
NOTE 6: PRESSURE GAUGE PI489 INSTALLED CLOSE TO V467
NOTE 7: PRESSURE GAUGE PI493 INSTALLED CLOSE TO V458
SIAD M.I.
T.P.I.
LIMIT OF SUPPLY
CLIENT BIOPLUS LNG
FACTORY RENZENHOF (GERMANY)
OBJECT NATURAL GAS TREATMENT CO2 REMOVAL AND DRYING NATURAL GAS PRECOOLING AND DRYING UNIT
0C REVISIONE - Revision 13/03/2023 FR CA DS
0B REVISIONE - Revision 22/02/2023 FR CA DS
0A PRIMA EMISSIONE - First Issue 18/01/2023 FR CA DS
COMMESSA G22C20698
DATE 18/01/2023
ESEG. FR
TECNO PROJECT INDUSTRIALE
PLANTS AND TECHNOLOGY FOR THE INDUSTRIAL GASES
CURNO - BERGAMO - ITALY
SCALA 5
FORMAT A1
DISEGNO N° 2220698-0C-10-001
REV. 0C

PIPING AND INSTRUMENTATION DIAGRAM

PROJECT N° : / N° COMMESSA : L43374

PLANT TYPE : / TIPO IMPIANTO : LNG LIQUEFACTION PLANT / IMPIANTO LIQUEFAZIONE LNG

LOCATION : / LOCALITA' : RENZENHOF (Germany) / RENZENHOF (Germania)

CUSTOMER : / CLIENTE : BIOPLUS LNG GmbH

SHEET	DESCRIPTION
1A	Cover sheet
2A	Instrument and valve legend
3A	Symbols sheet
4A	Revisions
10	Natural gas inlet
11	NG reduction station for steam boiler
15	Natural gas treatment and dryer
16	Steam condensation and condensate subcooling
20	Liquefier cold box LNG
22	Liquefier cold box LNG
23	Liquefier cold box LNG
25	Nitrogen recycle compressor
26	Nitrogen booster
27	Nitrogen turbine
30	LNG storage
31	LNG storage
32	LNG truck loading pump
33	LNG truck loading pump
34	Truck loading bay
35	Truck loading bay
36	NG regeneration cooler
37	NG regeneration heater
37A	NG regeneration compressor
37B	NG regeneration compressor
38	HC heater
38A	BOG compressor
38B	BOG compressor

SHEET	DESCRIPTION
39A	Cold flare
39B	Hot flare
40	Liquid nitrogen storage
41	Liquid nitrogen storage
42	Nitrogen distribution system
43	Instrument air distribution system
50	Steam boiler
51	Chiller
60	Instrument air package
65	Cooling water system
66	Cooling water system
67	Cooling water system
68	Demi water package
70	Thermal oxidizer
74	Analysis pumps
75	Analysis room
80	Motors control typical
81	Heaters control typical
82	ESD valves typical

Projekt - Nr.	Standort / Projektname
DG-001115	LNG LIQUEFACTION PLANT

	Datum	Name
Erst.	13.03.2023	CAGLIONI
Gepr.	13.03.2023	SORU
Freig.	13.03.2023	ANTONELLI

Zeichnungsbenennung

PIPING AND INSTRUMENTATION DIAGRAM
ROHRLEITUNGEN UND INSTRUMENTIERUNGSDIAGRAMM

Schutzvermerk	Blattgr.	Maßst. 1/
Schutz- vermerk ISO 16016 beachten	-	-

F-Tech	Standortkurzname	A-Art	Anl-Nr	A-Teil	D-Art	Lfd.-Nr	Blatt	Änd
520	REZH	700	001	000	SRI	002	01+	0C

Urspr.: I20784 Rev.0C Ers.f.: Ers.d.:

520REZH700001000SRI00201+0C.dwg

VALVE LEGEND CODE

FIRST LETTER / FUNCTION		TAG NUMBER	LAST LETTERS / FLUID
MANUAL VALVE	AUTOMATIC VALVE	MANUAL OR AUTOMATIC VALVE	MANUAL VALVE
A B BYPASS C CONTROL D DRAINS E F G H HIGH PRESSURE DIFFERENTIAL TAP I J SIGHT GLASS K FILTER L LOW PRESSURE DIFFERENTIAL TAP M N O P PRESSURE TAP Q R S SAMPLE T THAW U V VENT W X SHUTOFF Y CHECK VALVE Z	SEE INSTRUMENT LEGEND CODE IDENTIFICATIONS LETTERS	SEE INSTRUMENT LEGEND CODE AREA IDENTIFICATION NUMBERS	SEE FLUID LEGEND CODE

FLUID LEGEND CODE

ITEM	FLUID
	OILS
GO	GAS OIL
DO	DIATERMIC OIL
LO	LUBE OIL
	AIR AND GAS GENERAL USE
G	GAS (GENERAL)
IG	INSTRUMENT GAS
NG	NATURAL GAS / METHANE / BIOMETHANE
PG	PURGE GAS
FG	FUEL GAS
GF	FLUORURATE GAS
TG	THAW GAS
RG	REGENERATION GAS
GR	REFRIGERATING GAS
LR	REFRIGERATING LIQUID
A	AIR (GENERAL)
CA	COMPRESSED AIR
UA	UTILITIES AIR
	WATER
W	WATER (GENERAL)
CW	COOLING WATER
DW	DRINKING WATER
FW	FIRE FIGHTING WATER

ITEM	FLUID
	WATER
HW	HOT WATER
SW	SALT WATER
TW	TREATED WATER
UW	UTILITIES WATER
BW	BOILER FEED WATER / DEMI
IW	SERVICE WATER
	CONDENSATE AND STEAM
S	STEAM (GENERAL)
KS	HIGH PRESSURE STEAM
WS	MEAN PRESSURE STEAM
LS	LOW PRESSURE STEAM
KC	HIGH PR.STEAM COND.
WC	MEAN PR.STEAM COND.
LC	LOW PR.STEAM COND.
CD	CONDENSATE DISCHARGE
	PROCESS GAS AND LIQUID
D	ACETYLENE
NH3	AMMONIA
Q	ETHYLENE
H	HYDROGEN

ITEM	FLUID
	PROCESS GAS AND LIQUID
CO	CARBON OXIDE
K	CARBON DIOXIDE
NO	NITROGEN OXIDE
FF	FIRE FOAM
FL	FOAMING LIQUID
CH	CHEMICAL
GY	GLYCOL
BO	BLOW DOWN
SG	SLUDGES
DR	DRAINS
V	ATMOSPHERE DISCHARGED
P	PROPANE/PROPYLENE
GV	GASES MIXTURE
HC	HYDROCARBONS
Ra	AMINE RICH
La	AMINE POOR
	CRYOGENIC GAS AND LIQUID
LIN	LIQUID NITROGEN
WLIN	LIQUID NITROGEN IMPURE
N	NITROGEN
WN	WASTE NITROGEN
R	ARGON
RR	WASTE ARGON
RP	PURE ARGON

ITEM	FLUID
	CRYOGENIC GAS AND LIQUID
RL	LIQUID ARGON
HPN	HIGH PRESSURE NITROGEN
HPO	HIGH PRESSURE OXYGEN
HPR	HIGH PRESSURE ARGON
LA	LIQUID AIR
KL	KETTLE
E	HELIUM
X	OXYGEN
LOX	LIQUID OXYGEN
GOX	GAS OXYGEN
KG	ENRICHED GAS
CL	CRYOGENIC LIQUID
LNG	NATURAL GAS / METHANE / BIOMETHANE LIQUID
NGL	NGL NATURAL GAS LIQUID
	BIOGAS
BGLP	BIOGAS LOW PRESSURE < 0.5 bar
BGHP	BIOGAS HIGH PRESSURE

INSTRUMENT LEGEND CODE

	IDENTIFICATIONS LETTERS				
	FIRST LETTER / FUNCTION		SUCCEDING LETTERS		
	MEASURED VARIABLE	MODIFIER	PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSYS		ALARM		
B	FLAME DETECTOR				
C	CONDUCIVITY			CONTROL	
D	DENSITY	DIFFERENTIAL			
E	VOLTAGE (E.F.M.)		PRIMARY ELEMENT		
F	FLOW RATE	RATIO			
G	GAUGING		GLASS		
H	HAND CONTROL				HIGH
I	CURRENT (ELECTR.)		INDICATE		
J	POWER	SCAN			
K	TIME			CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	MOISTURE				MIDDLE OR INTERM.
N	PNEUMATIC		PNEUMATIC	PNEUMATIC	PNEUMATIC
O			ORIFICE		
P	PRESSURE OR VACUUM		POINT		
Q	QUANTITY OR EVENT	INTEGR.OR TOTALIZE			
R	RADIOACTIVITY		RECORD		
S	SPEED OR FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMITTER	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION			VALVE	
W	WEIGHT OR FORCE		WELL		
X	UNCLASSIFIED	AXIS X	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y		AXIS Y		RELAY OR COMPUTE	
Z	POSITION	AXIS Z		UNCLASSIFIED FINAL CONTROL ELEMENT	

AREA IDENTIFICATION NUMBERS

	NUMBER	AREA
FISCAL METER 433	-	FISCAL METER
GAS TREATMENT 598	100 - 199	AVAILABLE FOR GAS TREATMENT
	200 - 299	AVAILABLE FOR GAS TREATMENT
	300 - 399	AVAILABLE FOR GAS TREATMENT
	400 - 499	AVAILABLE FOR GAS TREATMENT
	500 - 599	NG REGENERATION HEATER + REGENERATION COMPRESSOR
	600 - 699	NATURAL GAS INLET
LIQUEFACTION 599	700 - 739	COLD BOX LNG
	740 - 749	RECYCLE COMPRESSOR
	750 - 759	WARM TURBINE
	760 - 769	COLD TURBINE
UTILITIES tbd	770 - 799	AIR DISTRIBUTION SYSTEM
	800 - 899	WATER AND DEMI WATER CIRCUIT
	900 - 999	HC HEATER + BOG COMPRESSOR
	1000 -1099	ANALYZERS
	1100 -1299	CHILLED WATER CIRCUIT
	1300 -1499	AVAILABLE
	1500 -1599	STEAM SYSTEM
VENT 730	1600 -1699	COLD FLARE AND THERMAL OXIDIZER
STORAGE 646	1700 -1799	LIQUID NITROGEN STORAGE, NITROGEN DISTRIBUTION SYSTEM
	1800 - 1899	AVAILABLE
	1900 -1999	LNG STORAGE AND TRUCK LOADING
	2000 -2299	AVAILABLE

Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0B
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 2A

PROCESS LINES

- MAJOR PROCESS LINES
- SECONDARY PROCESS LINES
- AUXILIARY LINES
- EXISTING LINE
- INSULATED PIPING
- VIP - VACUUM INSULATED PIPING
- TRACED AND INSULATED PIPING
- PROCESS FLOW DIRECTION
- PROCESS LINE REDUCER
- TJ TRANSITION JOINT
- EXPANSION JOINT
- PROCESS LINE FLANGE
- LINE CHANGE INDICATION

PRIMARY ELEMENTS

- FE ORIFICE PLATE
- FE FLOW TUBE
- FE CORIOLIS
- FE VORTEX
- TE THERMOCOUPLE
- TE RESISTANCE BULB
- THERMOWELL
- INSTRUMENT TAP

BODY SYMBOLS

- UNDEFINED
- GATE
- CHECK
- GLOBE
- BELLOWS SEALED
- SEGMENT BALL
- BUTTERFLY
- BALL / PLUG
- ANGLE
- THREE-WAY
- NEEDLE VALVE
- 2 VALVES MANIFOLD
- 3 VALVES MANIFOLD
- 5 VALVES MANIFOLD

AUTOMATIC VALVE ACTUATORS

- DIAPHRAGM
- X-XX mA DIAPHRAGM WITH POSITIONER
- DOUBLE ACTING PISTON
- ACTING PISTON SPRING RETURN

AUTOMATIC VALVE ACTIONS

- FO : FAIL OPEN
- FC : FAIL CLOSED

AUTOMATIC VALVE SUPPLY

- S_1 → UNREGULATED
- S_2 → REGULATED

BURSTING DISC

- PRESSURE
- EMPTY

MISCELLANEOUS SYMBOLS

- DRAIN
- CONDENSATE TRAP
- THAW GAS THAW MANIFOLD
- DM LIQUID DRAIN MANIFOLD
- FG SIGHT FLOW INDICATION
- TRUCK FILL HOSE
- BOUNDARY / LOCATION LINE
- MECHANICAL LINK
- QUIK DISCONNECT
- R REGULATOR
- F FILTER
- FR FILTER REGULATOR
- S SNUBBER
- Y FILTER
- SPECTACLE FLANGE
- CWR COOLING WATER RETURN
- CWS COOLING WATER SOURCE

INSTRUMENT TYPE & LOCATION

- LOCALLY MOUNTED
- FRONT PANEL MOUNTED
- REAR PANEL MOUNTED
- SECONDARY FUNCTION
- OPERATOR INTERFACE WITH CONTROL FUNCTION
- OPERATOR INTERFACE WITH SAFETY FUNCTION
- INTERNAL LOGIC FUNCTION
- OPERATOR INTERFACE DCS

FIELD EQUIPMENT SPEC. DRAWINGS

- CUSTOMER | SIAD M.I. — LIMIT OF SUPPLY
- SUBORDINATE SUPPLIER | SIAD M.I. — LIMIT OF SUPPLY

EQUIPMENT

- VENT SILENCER
- EXPANDER WITH NOZZLES
- DB PLATE
- BOOSTER
- SCREEN PROCESS LINE
- INTERCOOLER / HEATER EXCHANGER
- PROCESS LINE STRAINER
- FLOW RESTRICTOR
- M MOTOR
- FI VARIABLE AREA FLOW INDICATOR
- CENTRIFUGAL PUMP
- BREATHING DEVICE
- LNG SUBMERSIBLE PUMP
- BLOWER

SAFETY VALVES

- PRESSURE ACTUATED
- VACUUM ACTUATED
- PILOT OPERATED
- VACUUM / PRESSURE ACTUATED

SOLENOID VALVES

- S ELECTRIC TWO-WAYS
- S ELECTRIC THREE-WAYS (D=DE-ENERGIZED)
- PNEUMATIC TWO-WAYS
- PNEUMATIC THREE WAYS (D=DE-ENERGIZED)

INSTRUMENT CONNECTION

- CONNECTION TO PROCESS OR INSTRUMENT SUPPLY
- THERMAL CAPILLARY
- ELECTRICAL WIRING
- SOFTWARE LINK

PROCESS DATA

F	X
Q	Nm3/h
P	BAR (g)
T	°C
Ø	INCHES

REGULATORS

- INTERNAL PILOT
- EXTERNAL PILOT
- TEMPERATURE CONTROLLED

PIPING IDENTIFICATION (SIAD MI)

X - XX - X - XXX - X

- FLUID
- PIPE SIZE
- PROGRESSIVE NUMBER
- LINE SPECIFICATION
- INSULATON TYPE

- V = EXTERNAL PAINTING ONLY
- N = NOT PAINTED / NOT INSULATED
- F = INSULATION FOR LOW TEMPERATURE
- I = HOT INSULATION
- W = VACUUM INSULATION

- A = RATING 150 ANSI
- AB = RATING PN 10 DIN
- B = RATING 300 ANSI

CROSS REFERENCE

/1N.5C

- ORIGIN OR DESTINATION SHEET
- SHEET COORDINATES

Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 3A

REVISION	SHEET	ALTERATIONS	DATE	DRAWN	CHECKED
0A	ALL	Issue for approval	03/02/2023	M. Caglioni	F. Soru
0B	1A	Issue for approval	23/02/2023	M. Caglioni	F. Soru
	2A				
	3A				
	4A				
	11				
	15				
	20				
	22				
	23				
	25				
	27				
	30				
	31				
	32				
	33				
	34				
	35				
	36				
	37				
	37A				
	37B				
	38				
	38A				
	38B				
	39A				
	39B				
	40				
	41				
	42				
	50				
	51				
	65				

REVISION	SHEET	ALTERATIONS	DATE	DRAWN	CHECKED
0C	1A	Issue for approval	13/03/2023	M. Caglioni	F. Soru
	3A				
	4A				
	10				
	11				
	15				
	16				
	20				
	23				
	25				
	26				
	27				
	30				
	31				
	32				
	33				
	34				
	35				
	36				
	37				
	37A				
	37B				
	38				
	38A				
	38B				
	39A				
	39B				
	42				
	43				
	50				
	68				
	70				

Title	Job	Revision
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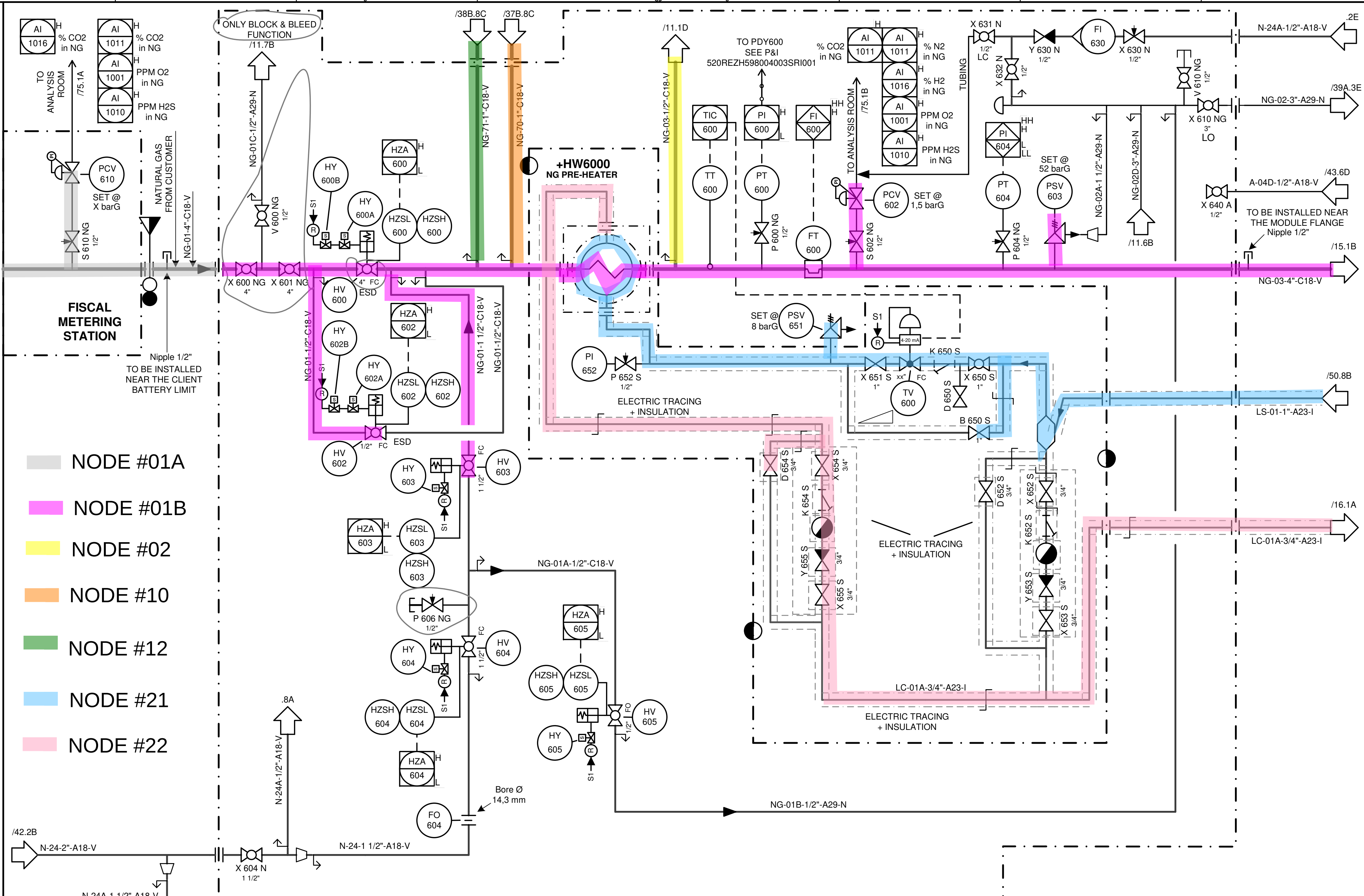
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 4A



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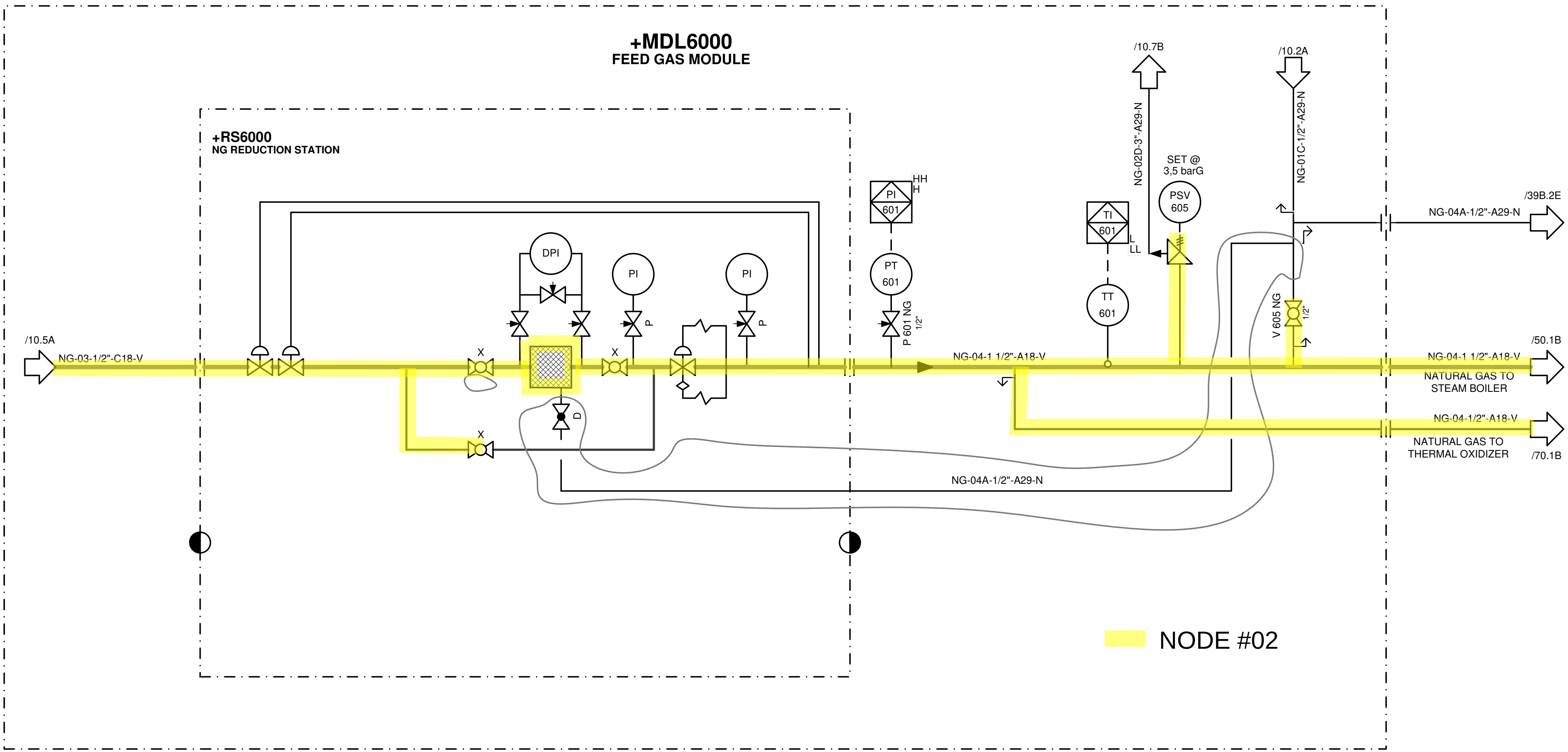
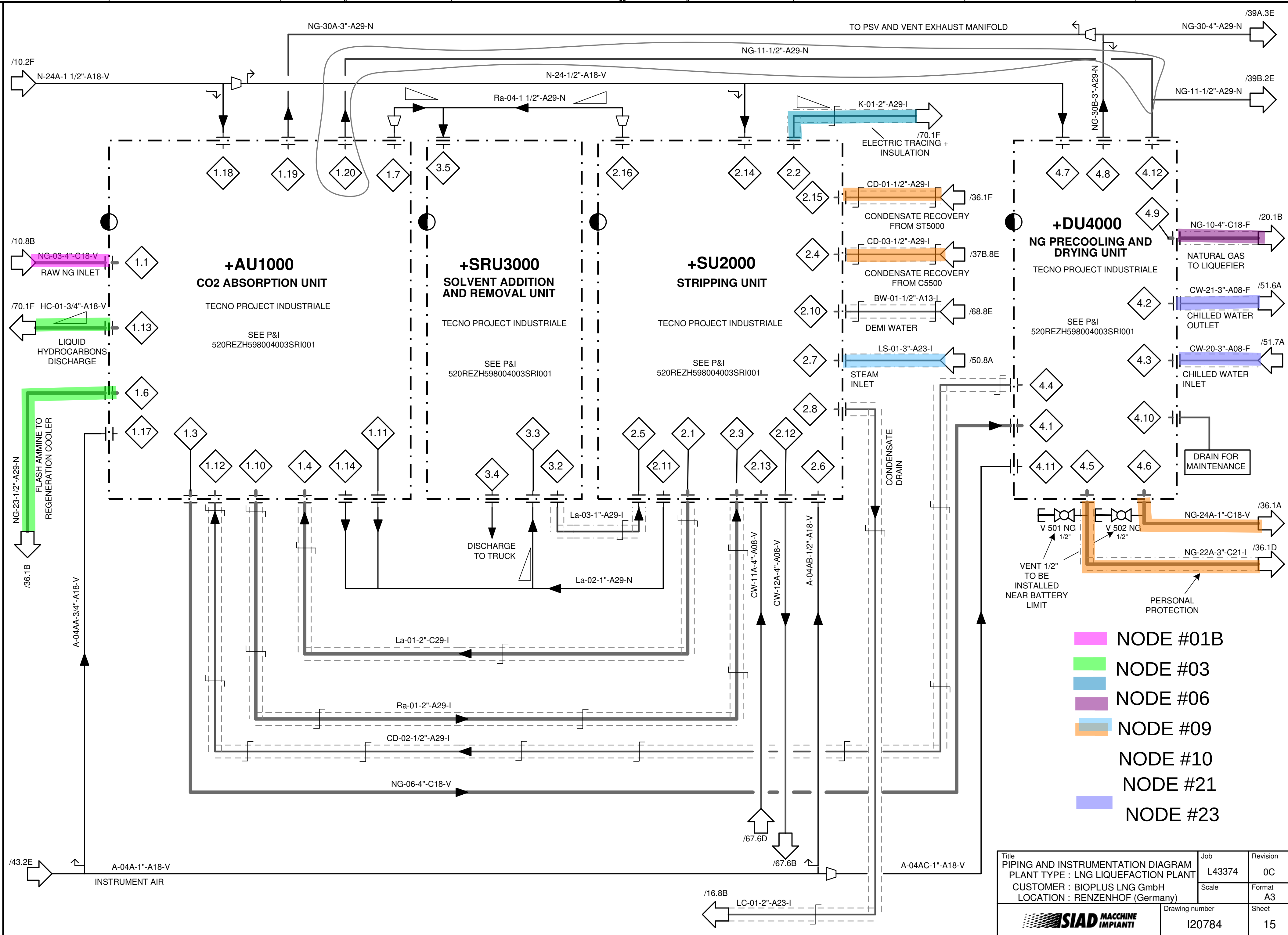
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 10



Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	Job: L43374	Revision: 0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale:	Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 11



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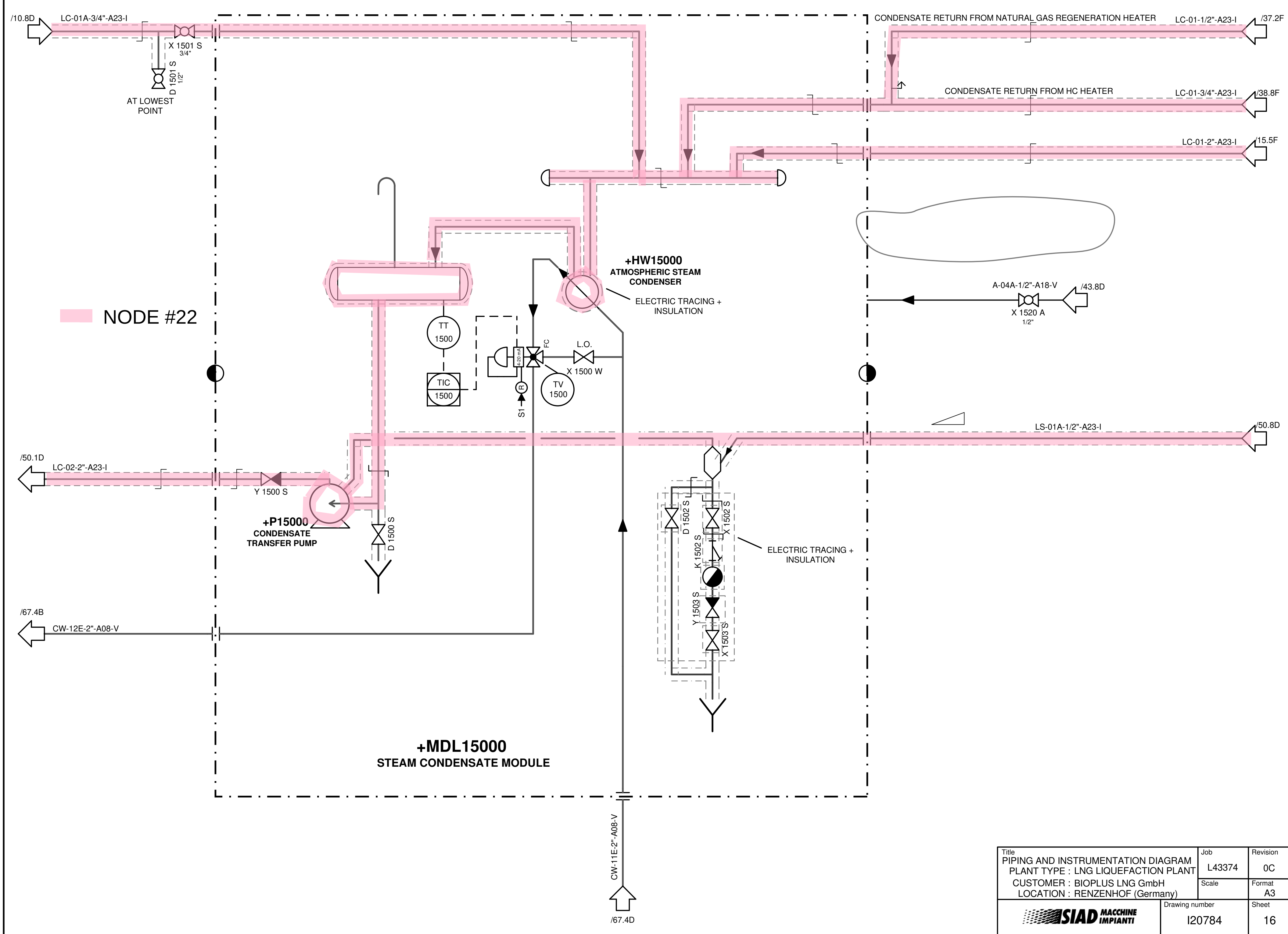
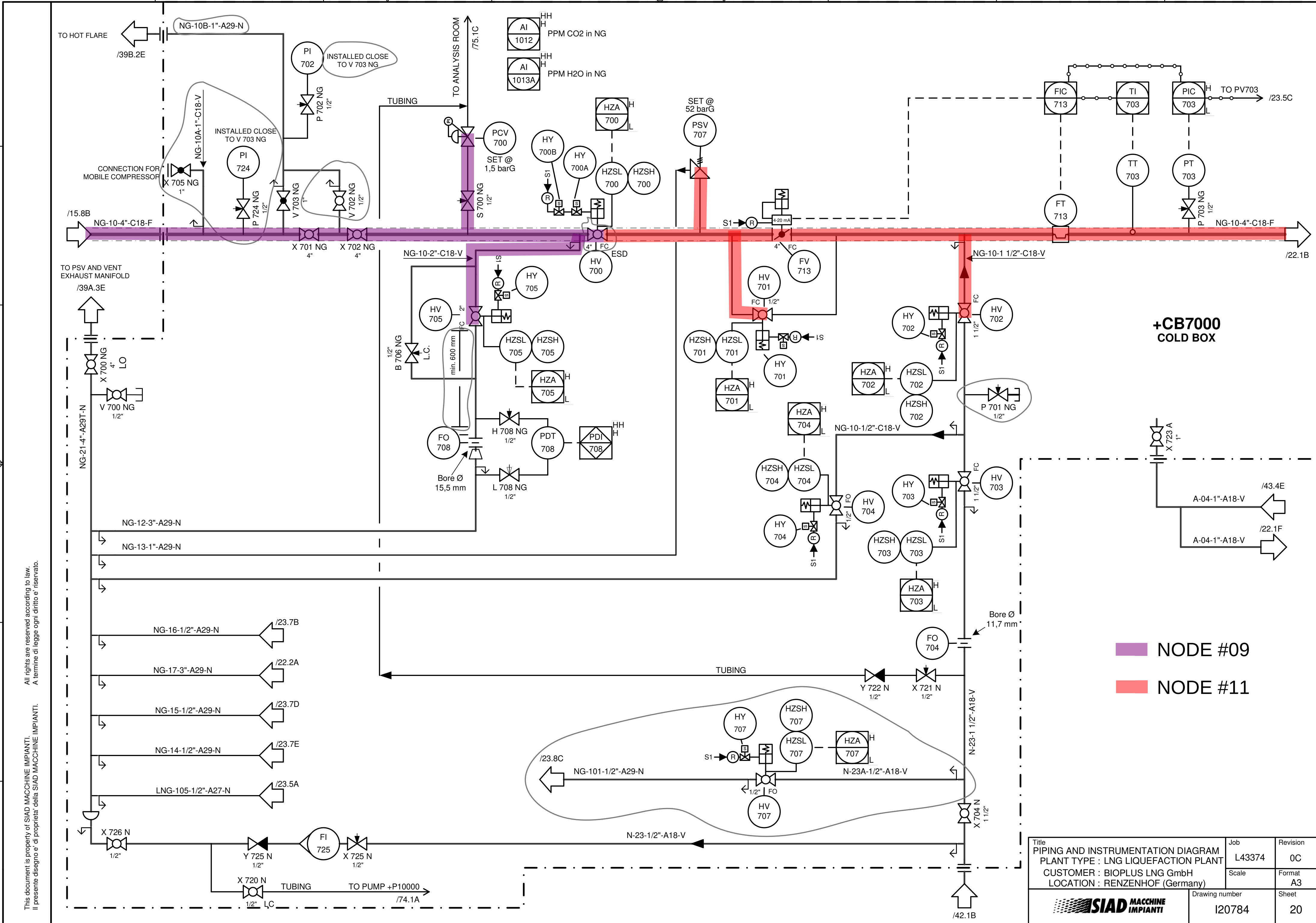
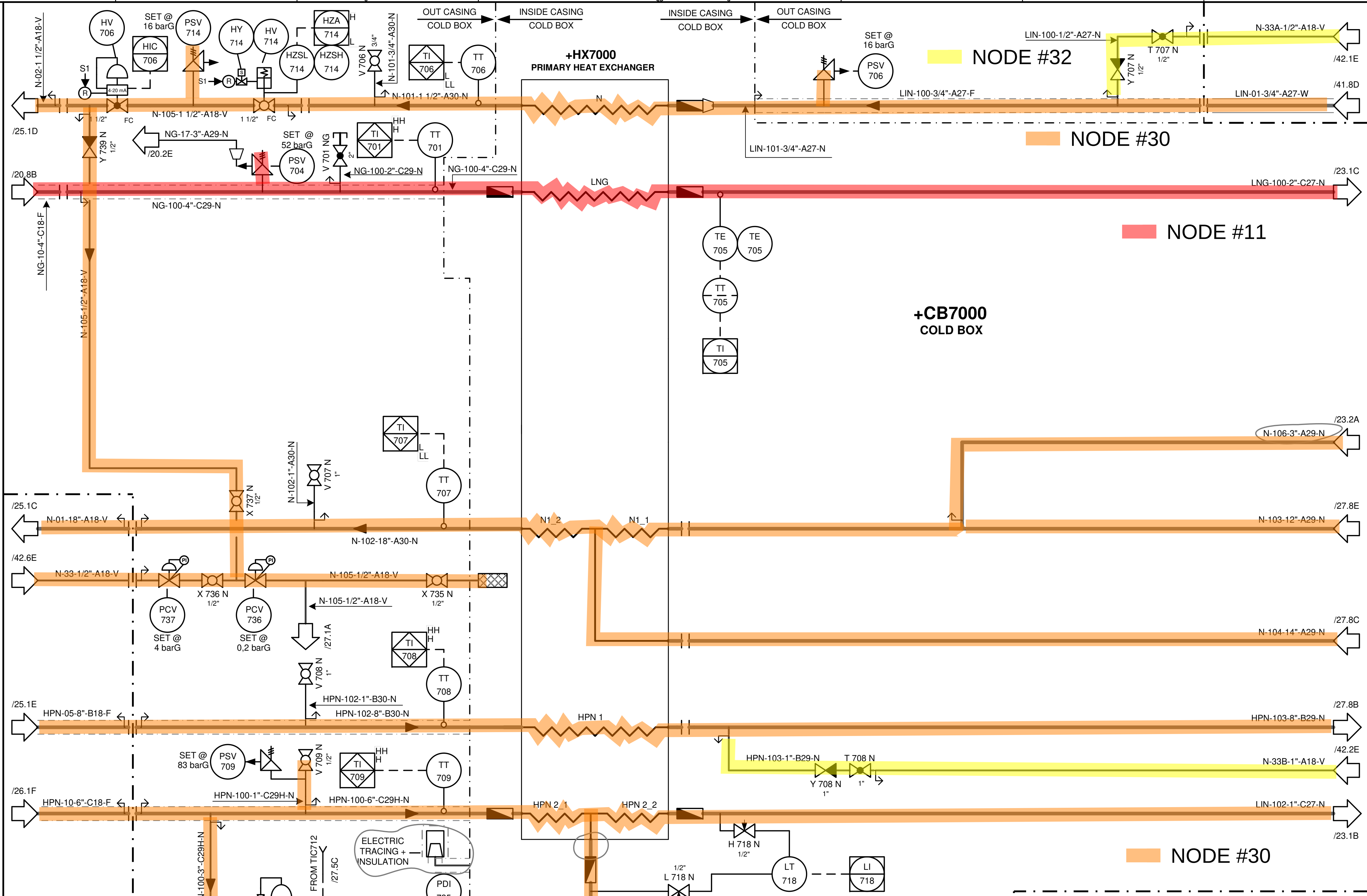
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 15



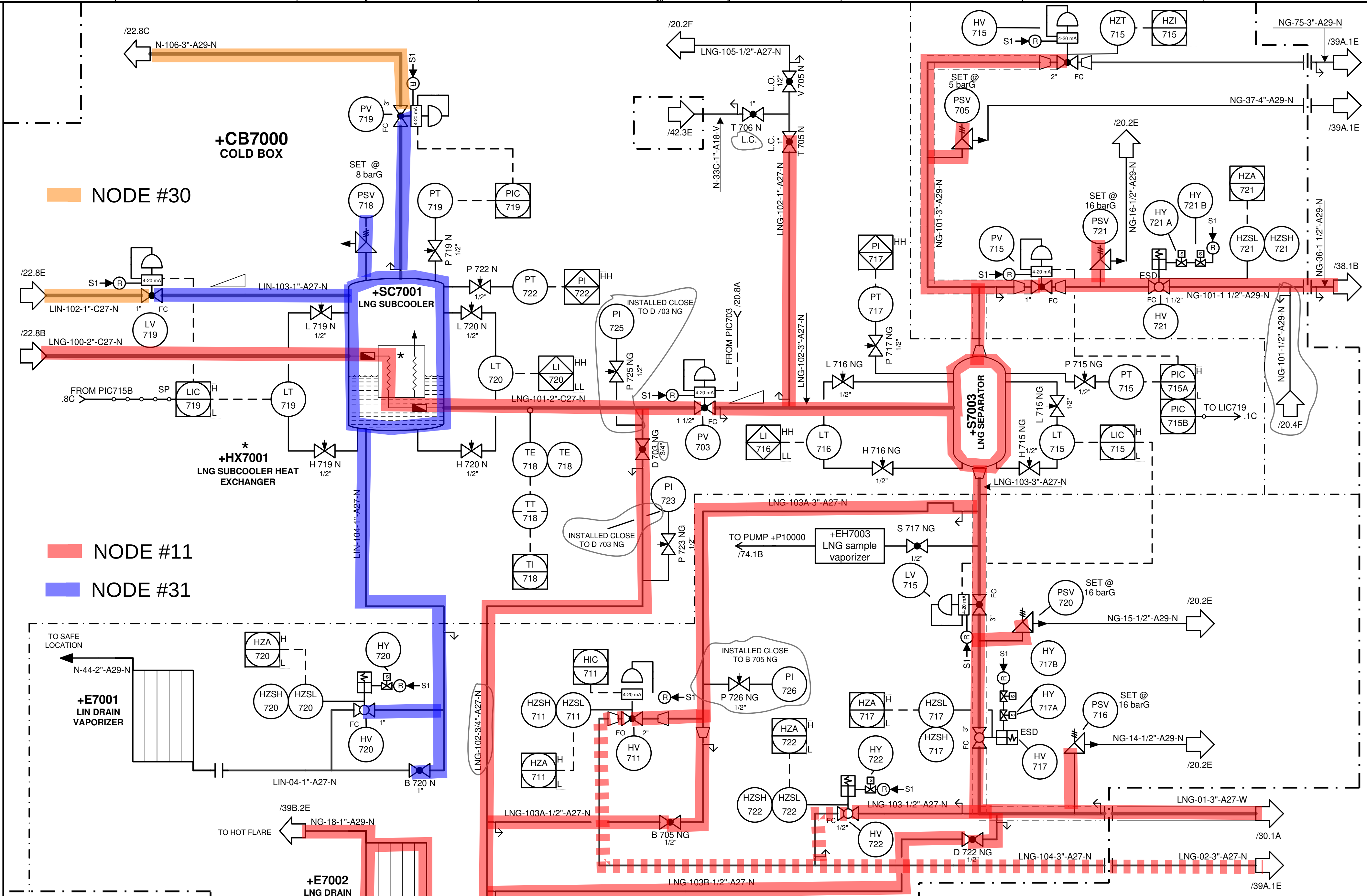
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 16



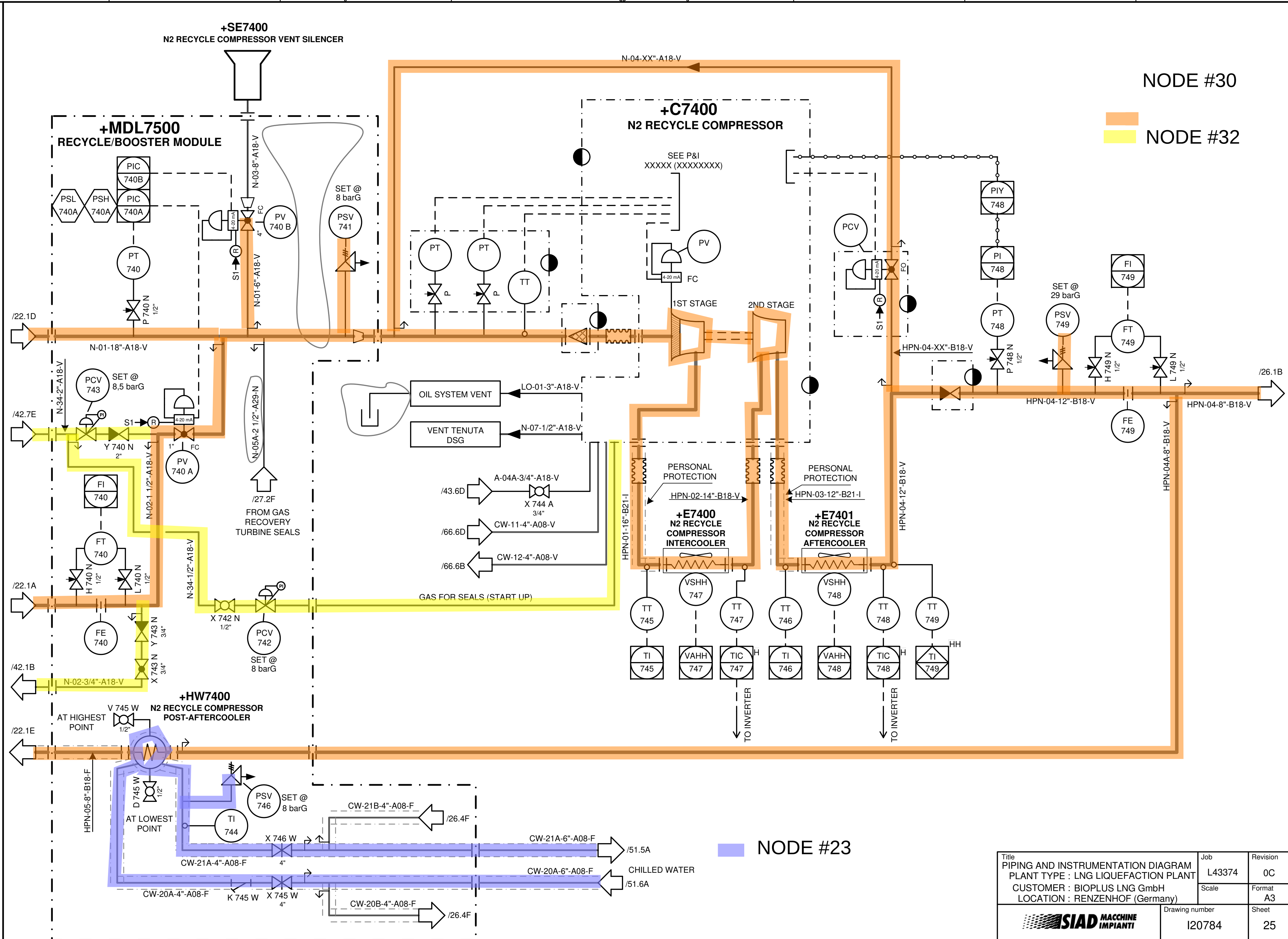
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 20



Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374		Revision: 0B
	Scale		Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784		Sheet: 22



Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374	Revision: 0C	
	Scale	Format: A3	
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 23	



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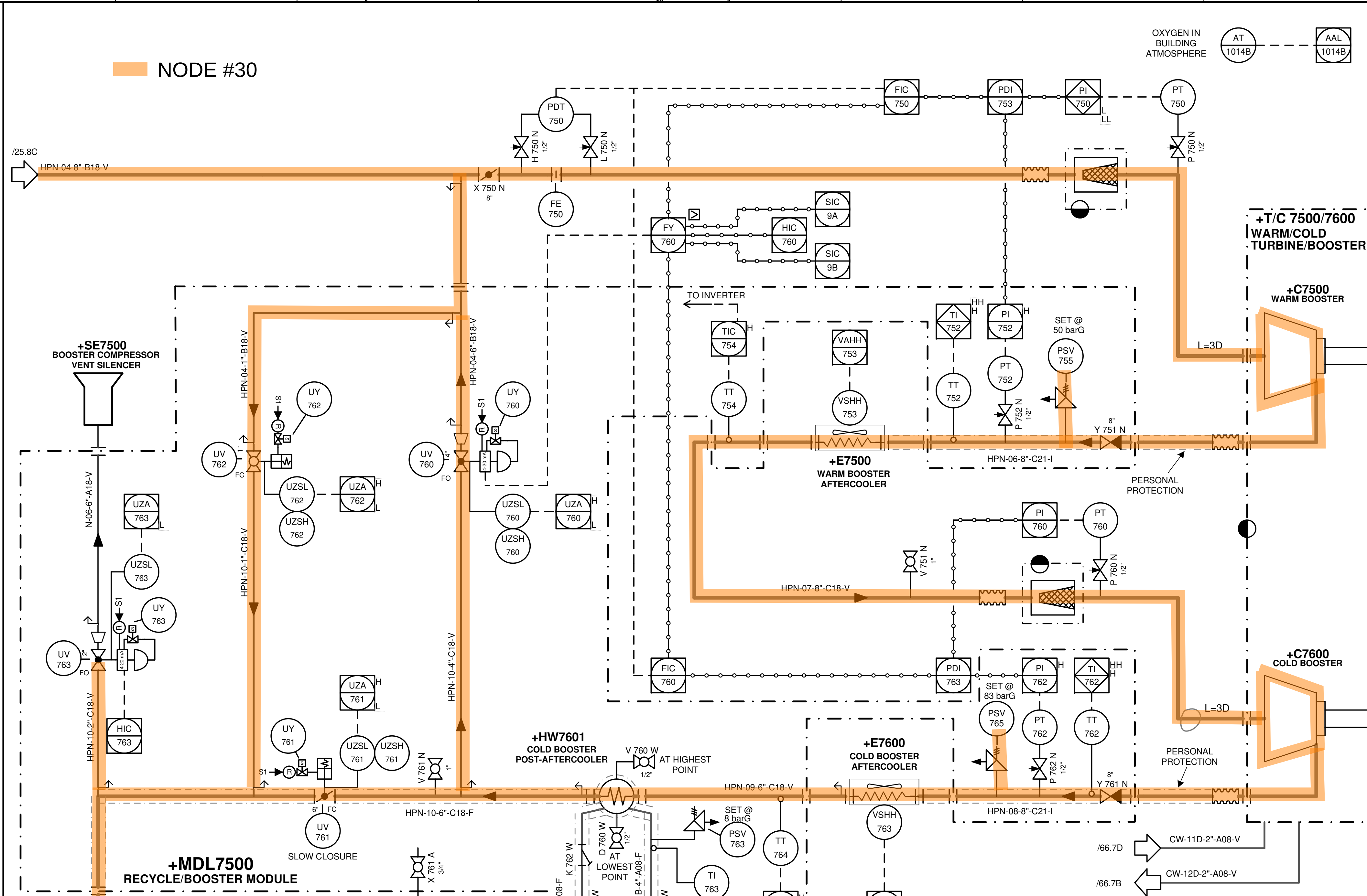
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 25



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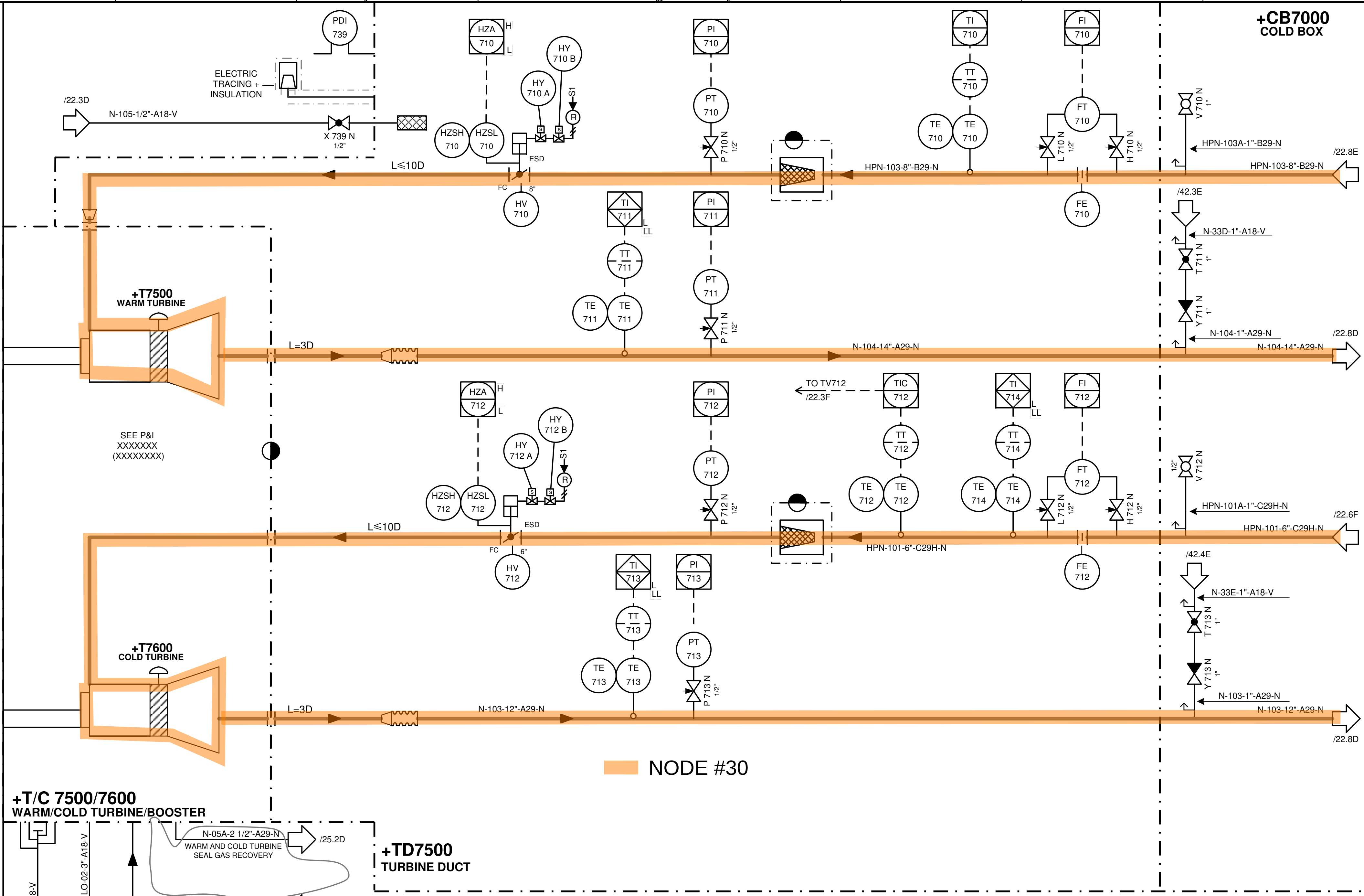
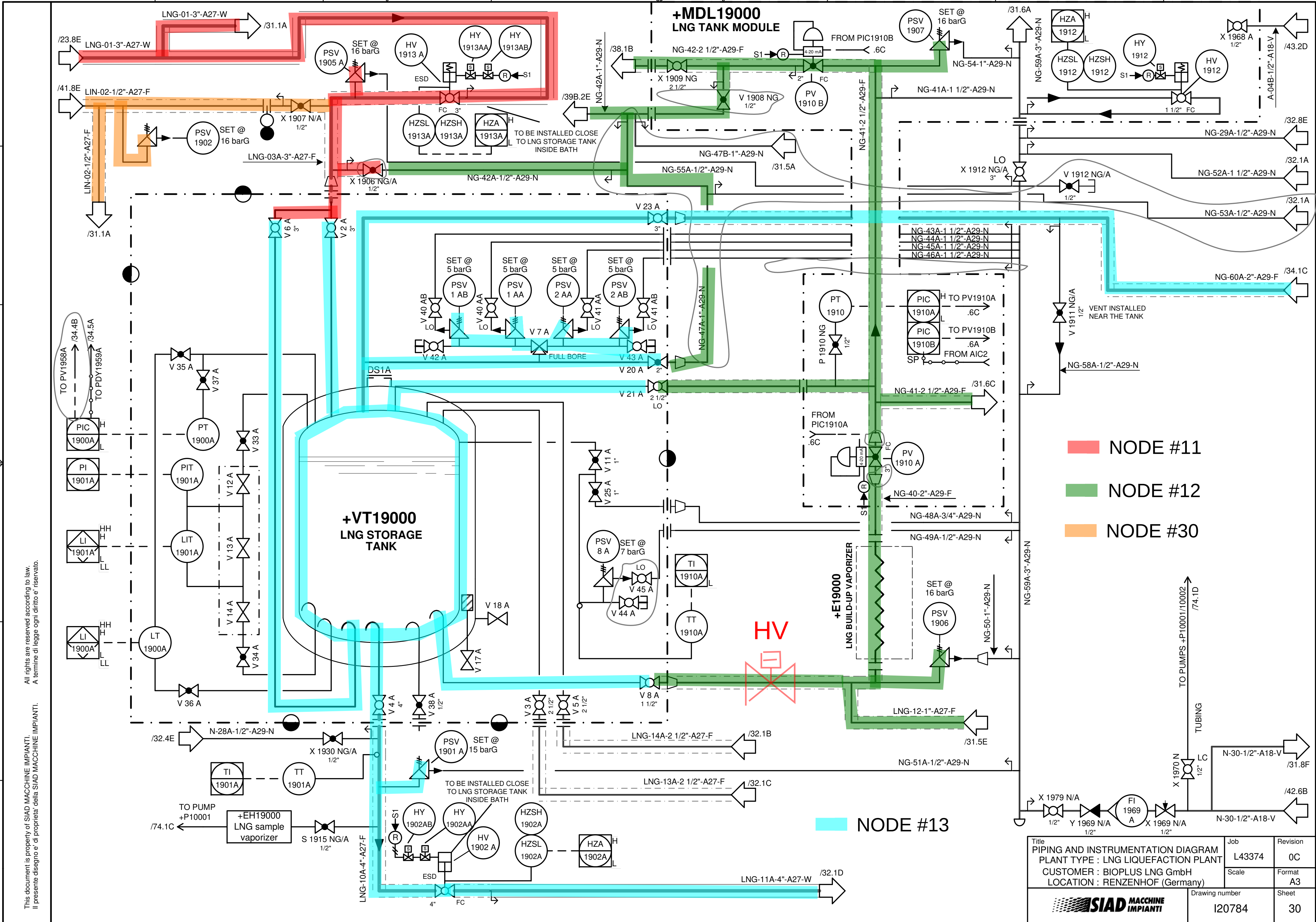
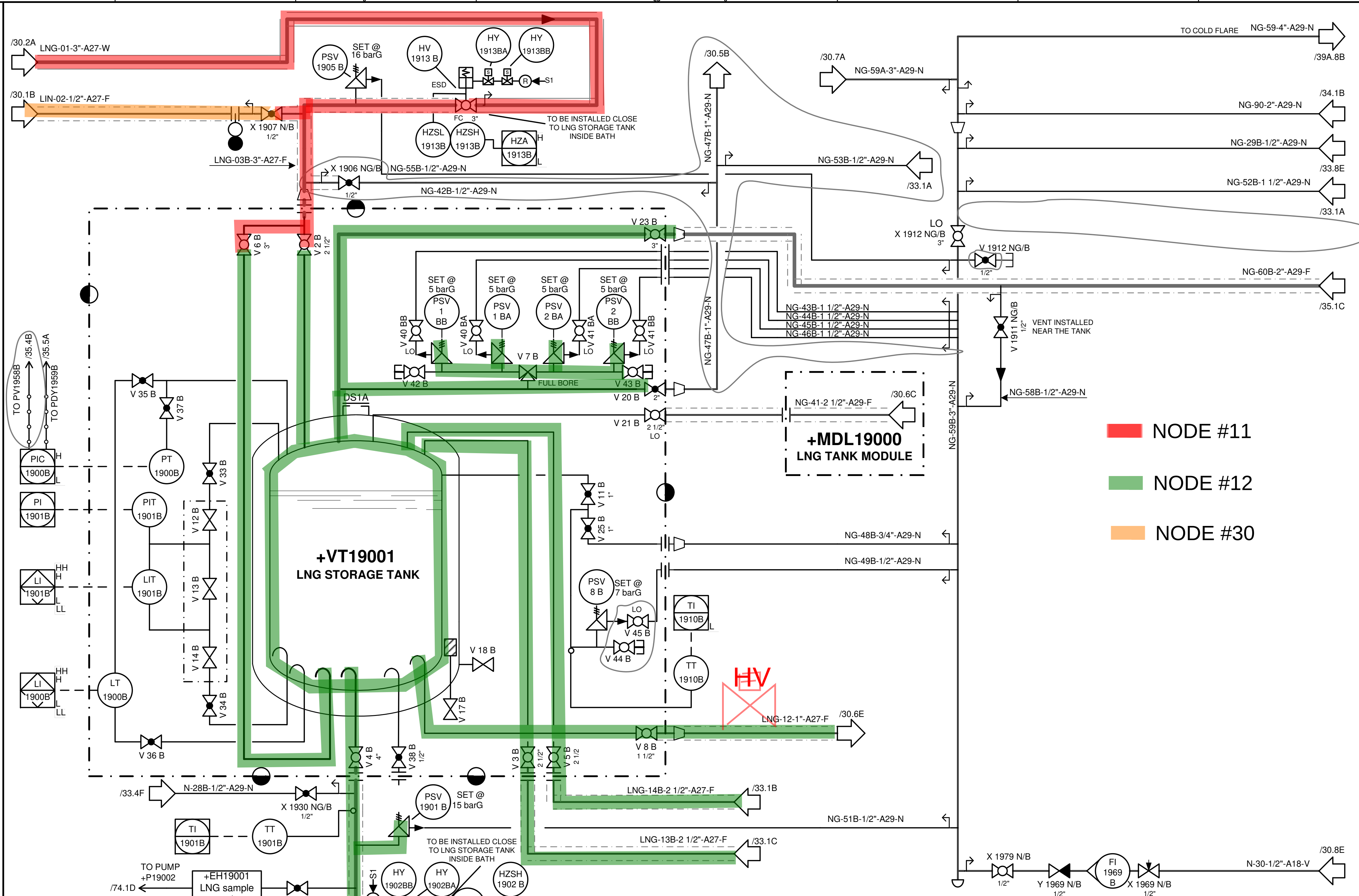
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 26

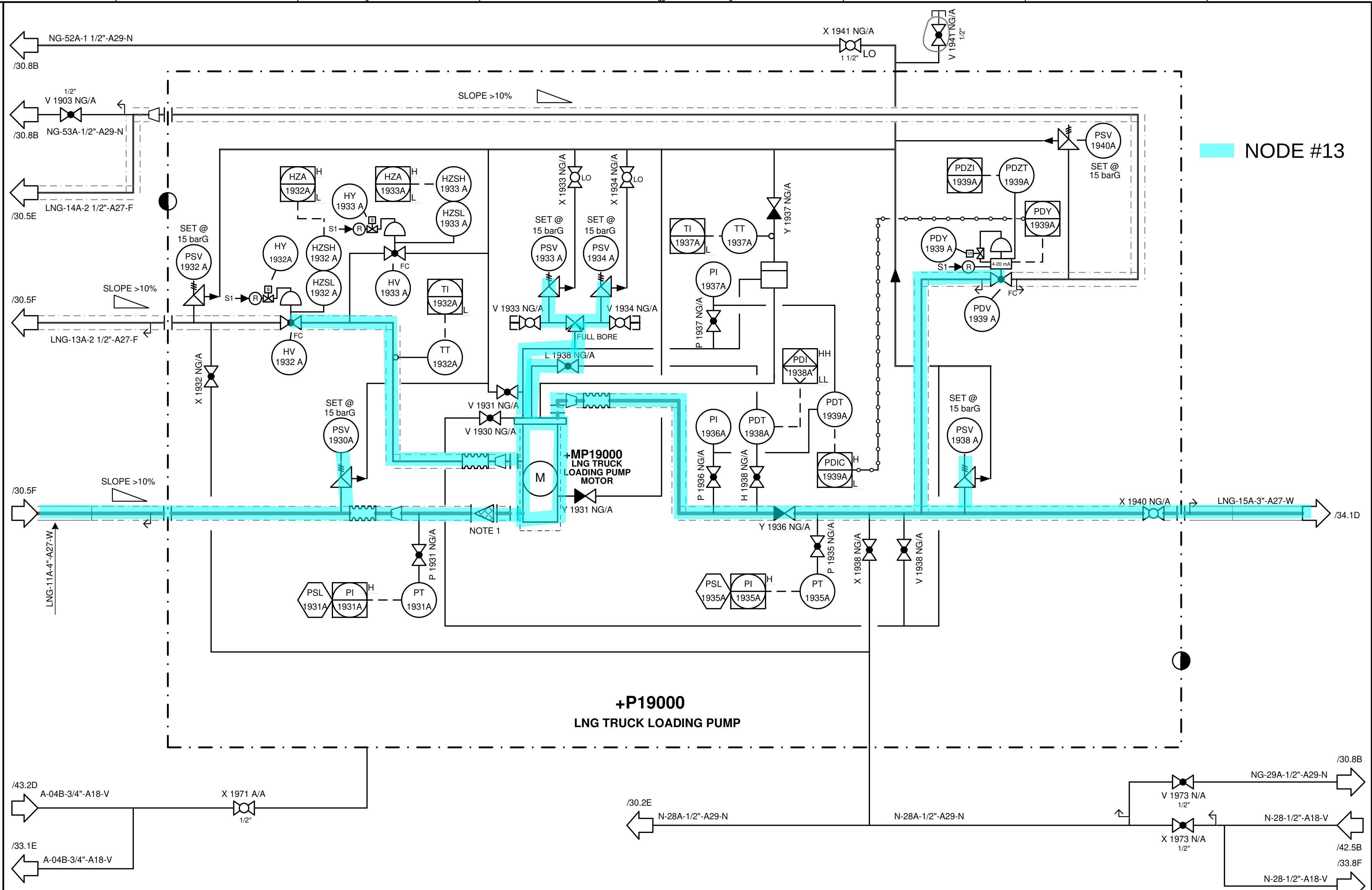


Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374		Revision: 0C
	Scale:		Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784		Sheet: 27


+MDL19000
LNG TANK MODULE
+VT19000
LNG STORAGE TANK
+E19000
LNG BUILD-UP VAPORIZER
NODE #11
NODE #12
NODE #30
NODE #13
HV
LNG-01-3"-A27-W
/31.1A
/23.8E
LIN-02-1/2"-A27-F
/41.8E
LIN-02-1/2"-A27-F
/31.1A
LNG-03A-3"-A27-F
PSV 1905 A
SET @ 16 barG
PSV 1902
SET @ 16 barG
X 1907 N/A
X 1906 NG/A
HV 1913 A
HY 1913AA
HY 1913AB
HZSL 1913A
HZSH 1913A
HZA 1913A
ESD
FC
TO BE INSTALLED CLOSE TO LNG STORAGE TANK INSIDE BATH
NG-42A-1/2"-A29-N
NG-42A-1"-A29-N
/38.1B
/39B.2E
NG-42-2 1/2"-A29-F
X 1909 NG
V 1908 NG
PV 1910 B
FROM PIC1910B
.6C
NG-47B-1"-A29-N
/31.5A
NG-55A-1/2"-A29-N
NG-41-2 1/2"-A29-F
NG-41A-1 1/2"-A29-N
PSV 1907
SET @ 16 barG
NG-54-1"-A29-N
/31.6A
HZA 1912
HZSL 1912
HZSH 1912
HY 1912
HV 1912
X 1968 A
/43.2D
A-04B-1/2"-A18-V
NG-59A-3"-A29-N
/32.8E
NG-29A-1/2"-A29-N
/32.1A
NG-52A-1 1/2"-A29-N
LO
X 1912 NG/A
V 1912 NG/A
NG-53A-1/2"-A29-N
NG-43A-1 1/2"-A29-N
NG-44A-1 1/2"-A29-N
NG-45A-1 1/2"-A29-N
NG-46A-1 1/2"-A29-N
/34.1C
NG-60A-2"-A29-F
V 23 A
V 6 A
V 2 A
PSV 1 AB
PSV 1 AA
PSV 2 AA
PSV 2 AB
SET @ 5 barG
V 40 AB
V 40 AA
V 41 AA
V 41 AB
V 7 A
V 42 A
V 43 A
FULL BORE
V 20 A
V 21 A
DS1A
NG-47A-1"-A29-N
PT 1910
P 1910 NG
PIC 1910A
PIC 1910B
TO PV1910A
TO PV1910B
FROM AIC2
SP
V 1911 NG/A
VENT INSTALLED NEAR THE TANK
NG-58A-1/2"-A29-N
NG-41-2 1/2"-A29-F
/31.6C
FROM PIC1910A
PV 1910 A
NG-40-2"-A29-F
NG-48A-3/4"-A29-N
NG-49A-1/2"-A29-N
TO PV1958A
/34.4B
TO PDY1959A
/34.5A
PIC 1900A
PT 1900A
PI 1901A
PIT 1901A
LI 1901A
LIT 1901A
LI 1900A
LT 1900A
V 35 A
V 37 A
V 33 A
V 12 A
V 13 A
V 14 A
V 34 A
V 36 A
V 11 A
V 25 A
PSV 8 A
SET @ 7 barG
V 45 A
V 44 A
TI 1910A
TT 1910A
V 18 A
V 17 A
V 8 A
PSV 1906
SET @ 16 barG
NG-50-1"-A29-N
LNG-12-1"-A27-F
/31.5E
V 4 A
V 38 A
V 3 A
V 5 A
/32.4E
N-28A-1/2"-A29-N
X 1930 NG/A
PSV 1901 A
SET @ 15 barG
LNG-14A-2 1/2"-A27-F
/32.1B
NG-51A-1/2"-A29-N
TI 1901A
TT 1901A
LNG-13A-2 1/2"-A27-F
/32.1C
TO PUMP +P10001
/74.1C
+EH19000 LNG sample vaporizer
S 1915 NG/A
HY 1902AB
HY 1902AA
HV 1902 A
HZSH 1902A
HZSL 1902A
HZA 1902A
LNG-10A-4"-A27-F
LNG-11A-4"-A27-W
/32.1D
TO PUMPS +P10001/10002
/74.1D
TUBING
X 1970 N
N-30-1/2"-A18-V
/31.8F
/42.6B
X 1979 N/A
Y 1969 N/A
FI 1969 A
X 1969 N/A
N-30-1/2"-A18-V
Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job
L43374
Revision
0C
Scale
Format
A3
Drawing number
I20784
Sheet
30

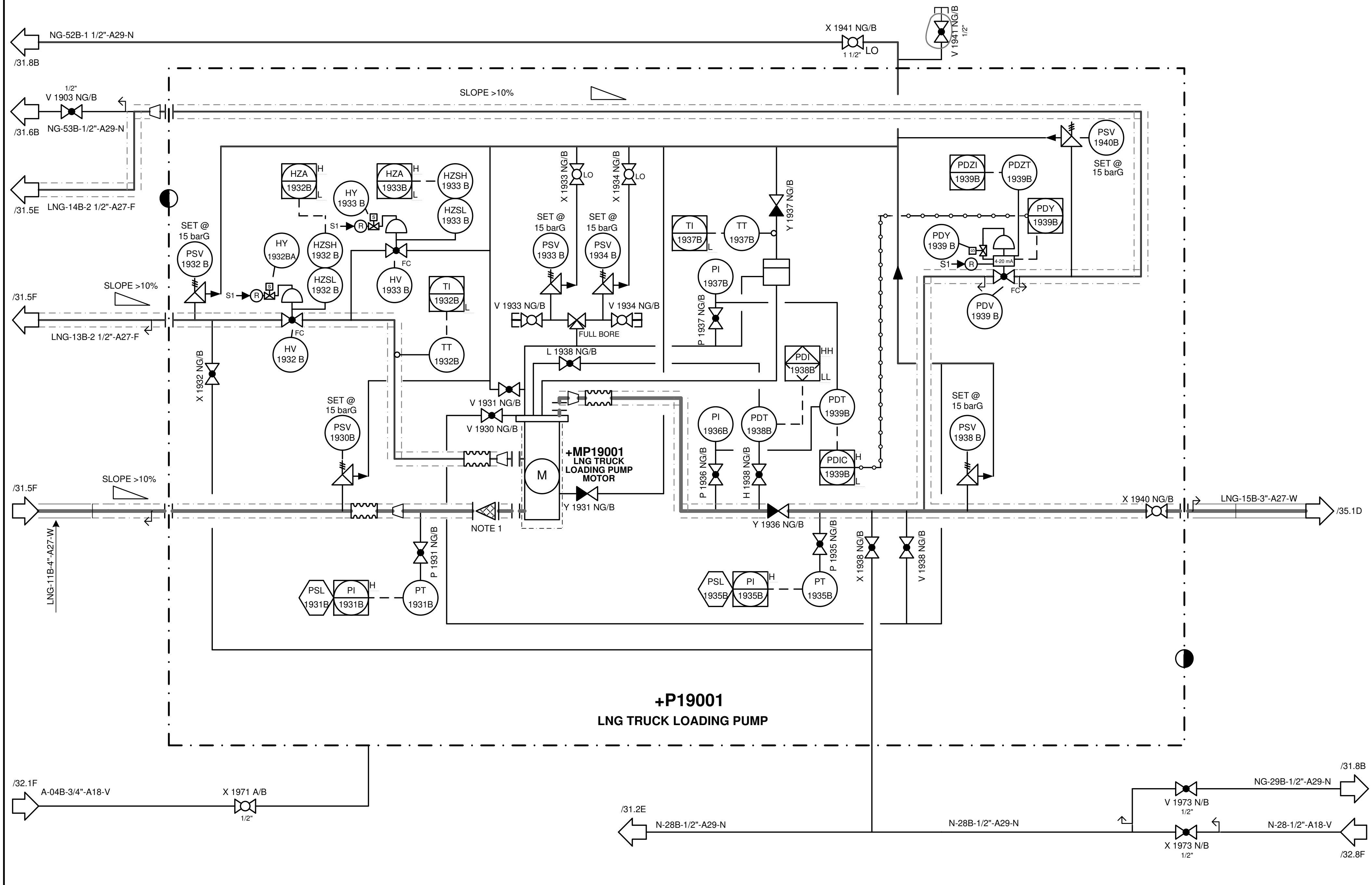


Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374 Scale:	Revision: 0C Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 31



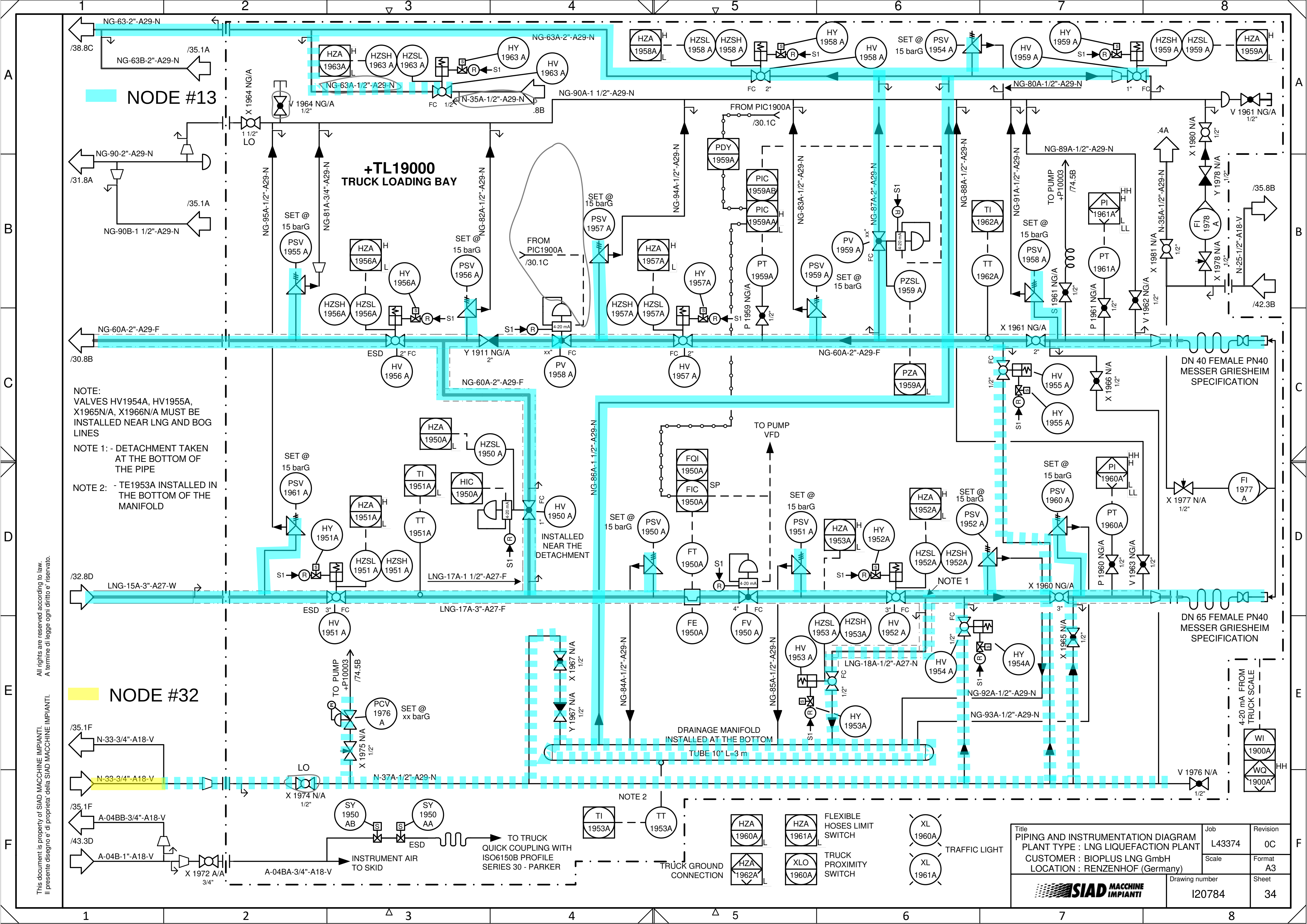
NOTE 1 - TEMPORARY FILTER

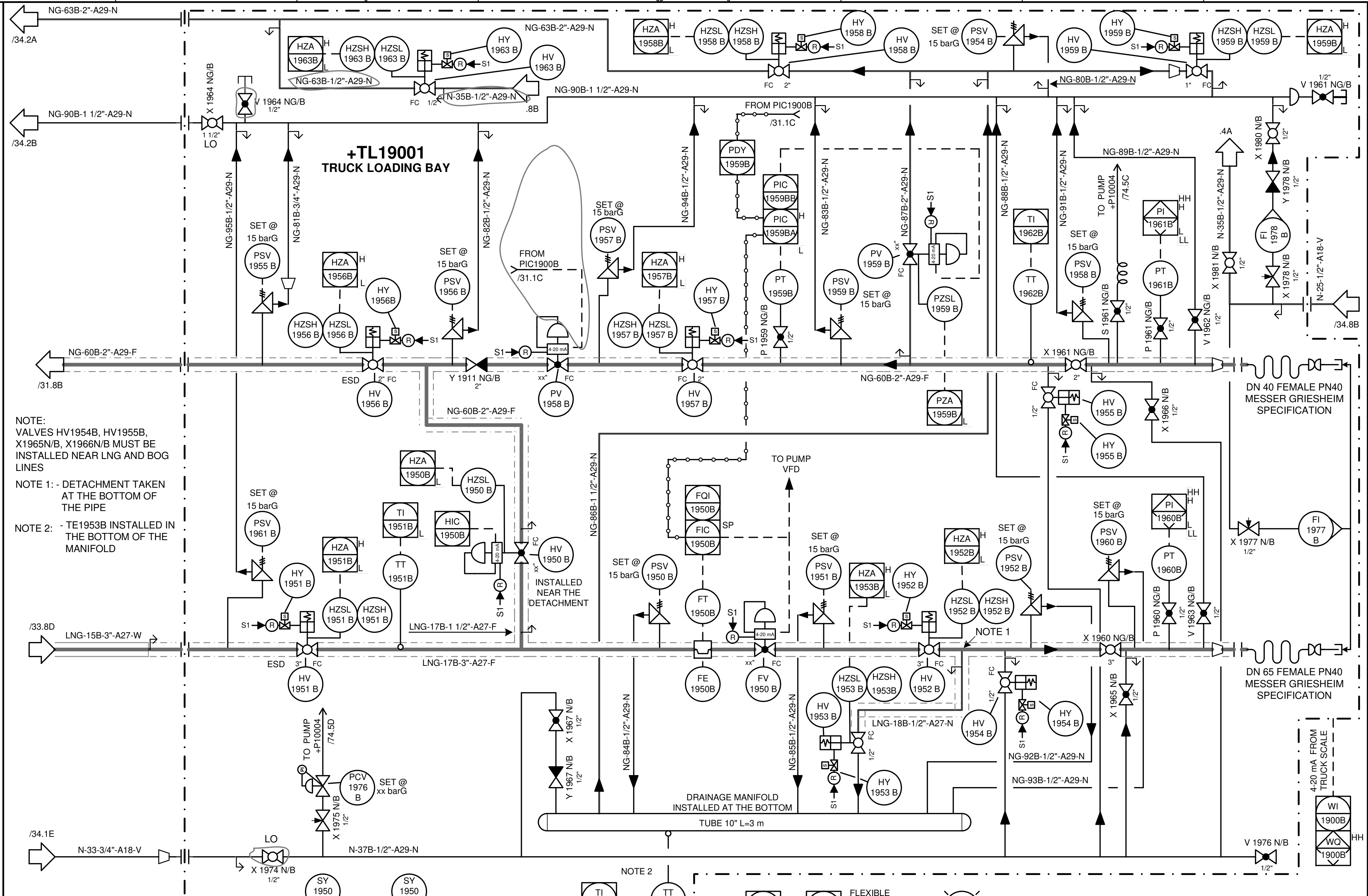
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 32



NOTE 1 - TEMPORARY FILTER

Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 33


NODE #13
NODE #32
+TL19000
TRUCK LOADING BAY
NOTE:
VALVES HV1954A, HV1955A, X1965N/A, X1966N/A MUST BE INSTALLED NEAR LNG AND BOG LINES
NOTE 1: - DETACHMENT TAKEN AT THE BOTTOM OF THE PIPE
NOTE 2: - TE1953A INSTALLED IN THE BOTTOM OF THE MANIFOLD
NG-63-2"-A29-N
NG-63A-2"-A29-N
NG-63B-2"-A29-N
NG-90-2"-A29-N
NG-90A-1 1/2"-A29-N
NG-90B-1 1/2"-A29-N
NG-60A-2"-A29-F
LNG-15A-3"-A27-W
LNG-17A-3"-A27-F
LNG-17A-1 1/2"-A27-F
N-33-3/4"-A18-V
N-37A-1/2"-A29-N
A-04BB-3/4"-A18-V
A-04B-1"-A18-V
A-04BA-3/4"-A18-V
DN 40 FEMALE PN40 MESSER GRIESHEIM SPECIFICATION
DN 65 FEMALE PN40 MESSER GRIESHEIM SPECIFICATION
INSTALLED NEAR THE DETACHMENT
DRAINAGE MANIFOLD INSTALLED AT THE BOTTOM
TUBE 10" L=3 m
TO PUMP VFD
TO TRUCK QUICK COUPLING WITH ISO6150B PROFILE SERIES 30 - PARKER
INSTRUMENT AIR TO SKID
FLEXIBLE HOSES LIMIT SWITCH
TRUCK PROXIMITY SWITCH
TRUCK GROUND CONNECTION
TRAFFIC LIGHT
4-20 mA FROM TRUCK SCALE
Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job
L43374
Revision
0C
Scale
Format
A3
Drawing number
I20784
Sheet
34
SIAD MACCHINE IMPIANTI

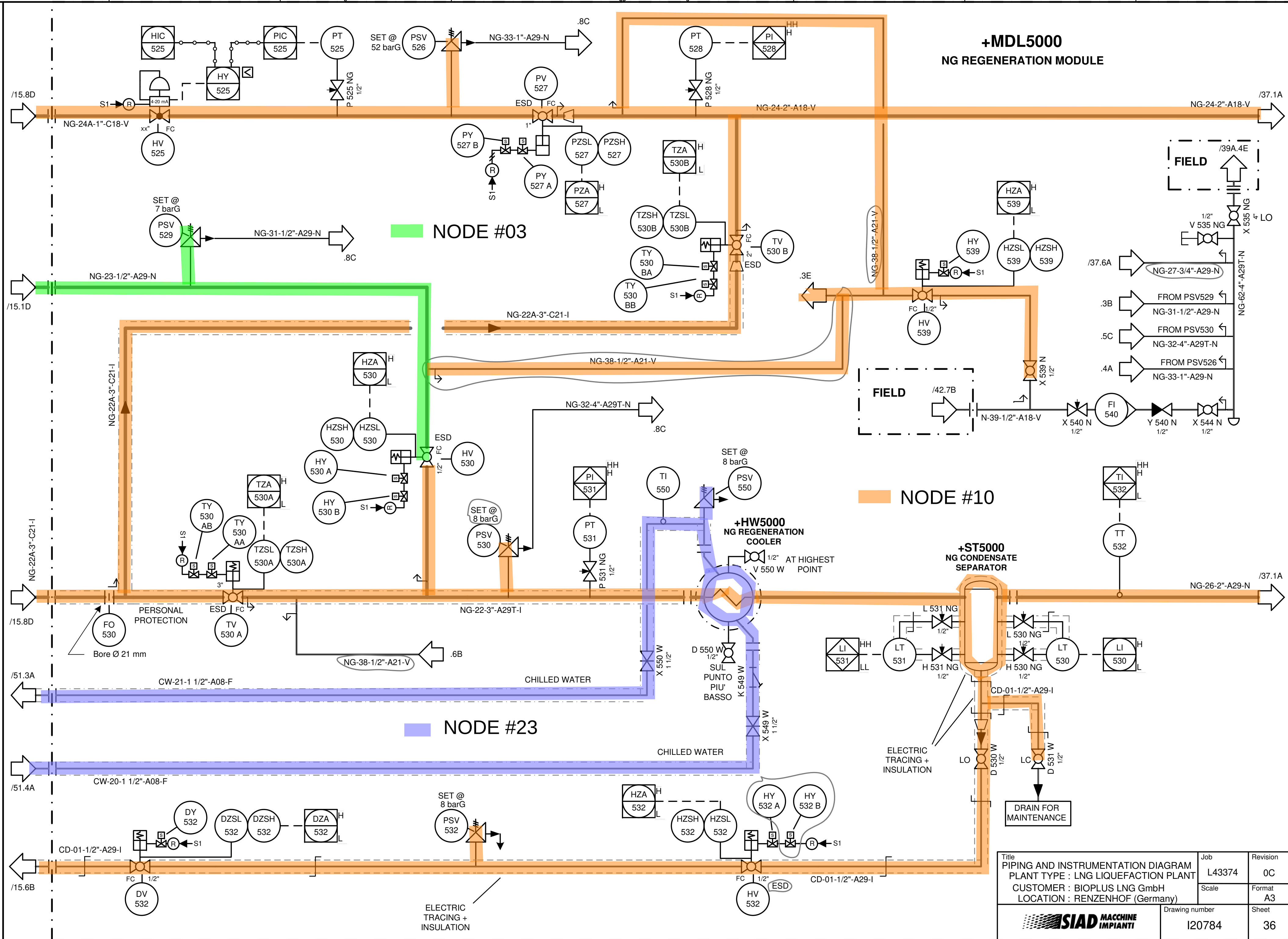


NOTE:
VALVES HV1954B, HV1955B, X1965N/B, X1966N/B MUST BE INSTALLED NEAR LNG AND BOG LINES

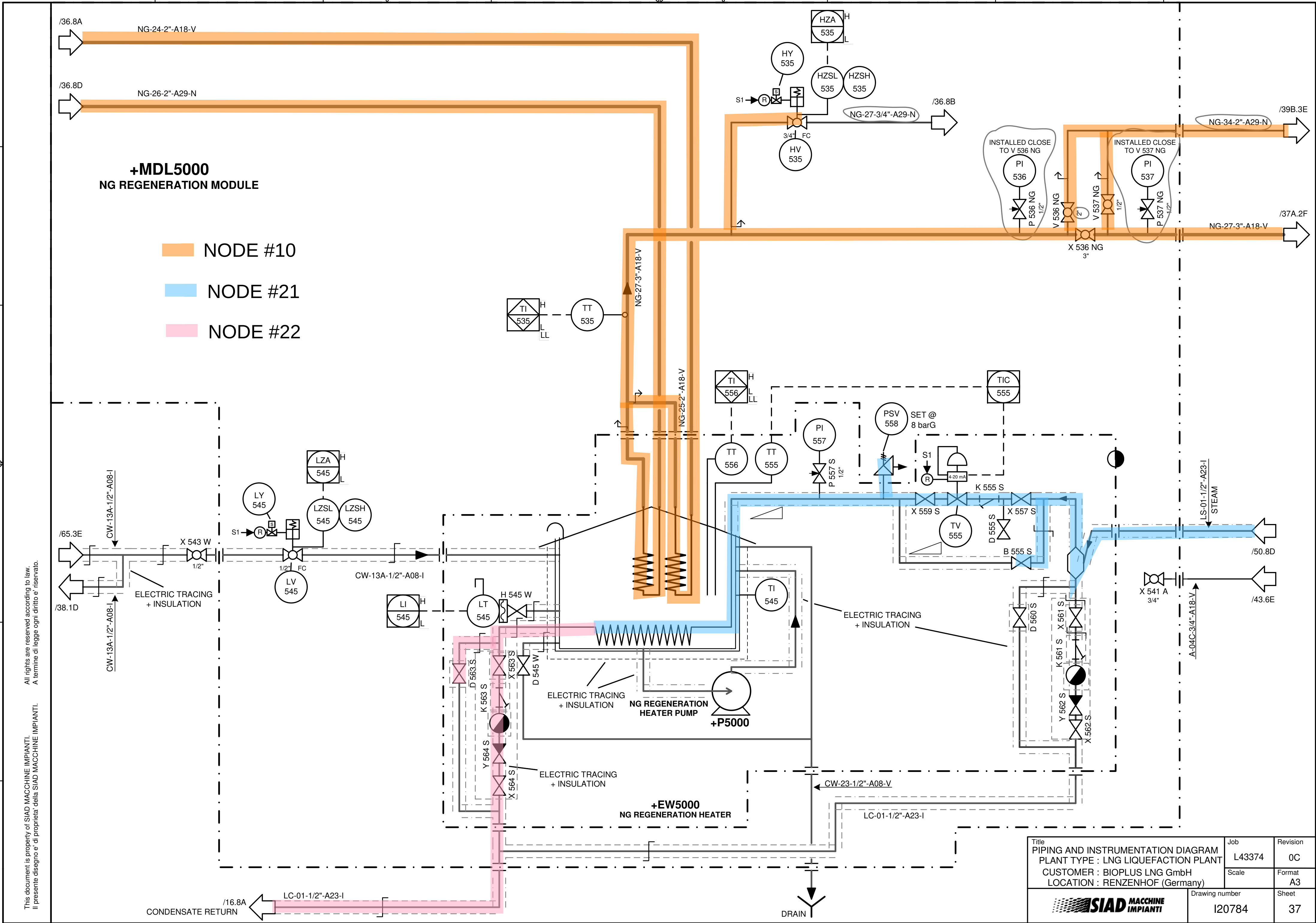
NOTE 1: - DETACHMENT TAKEN AT THE BOTTOM OF THE PIPE

NOTE 2: - TE1953B INSTALLED IN THE BOTTOM OF THE MANIFOLD

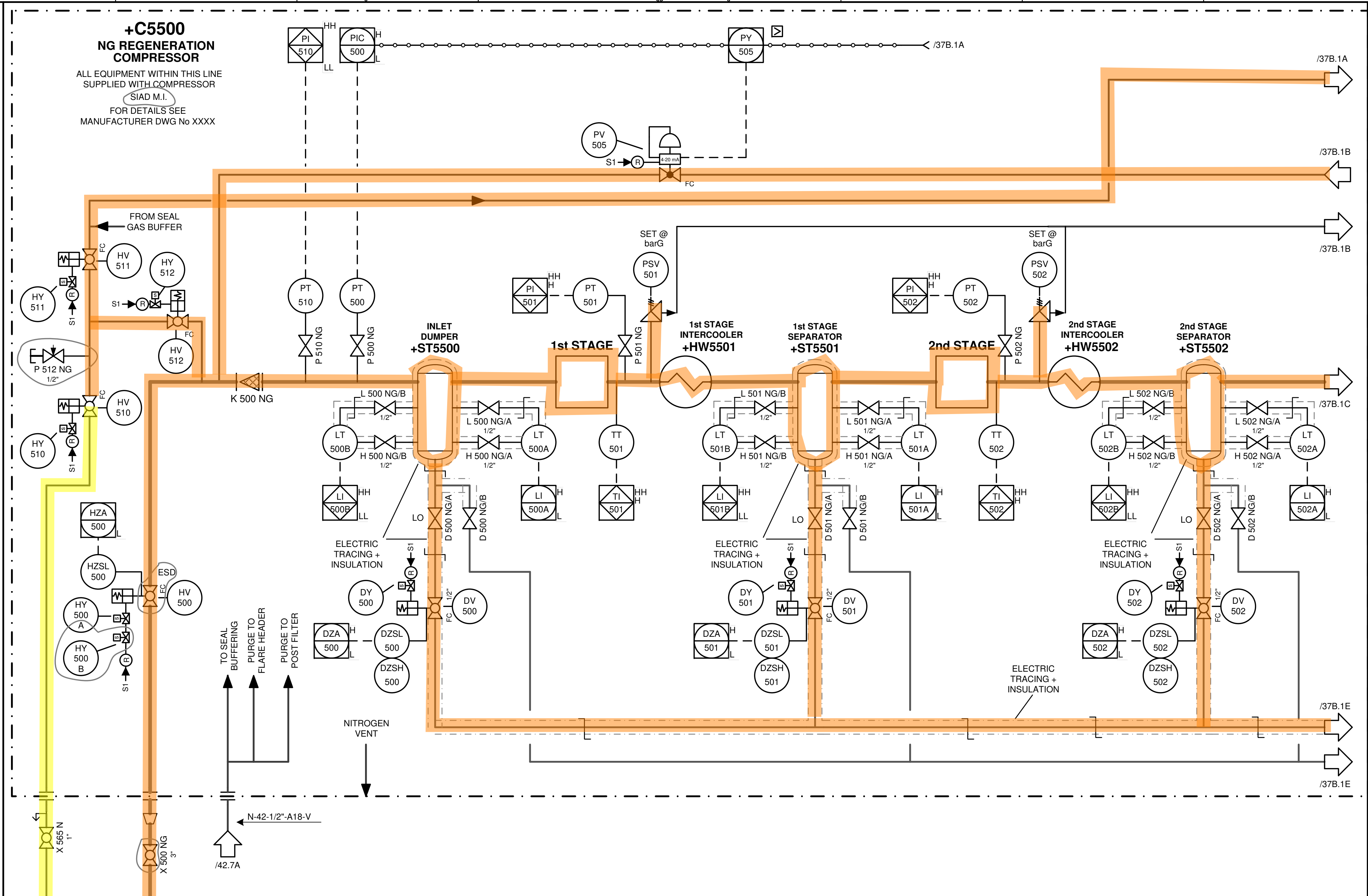
Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374	Revision: 0C	
	Scale	Format: A3	
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 35	



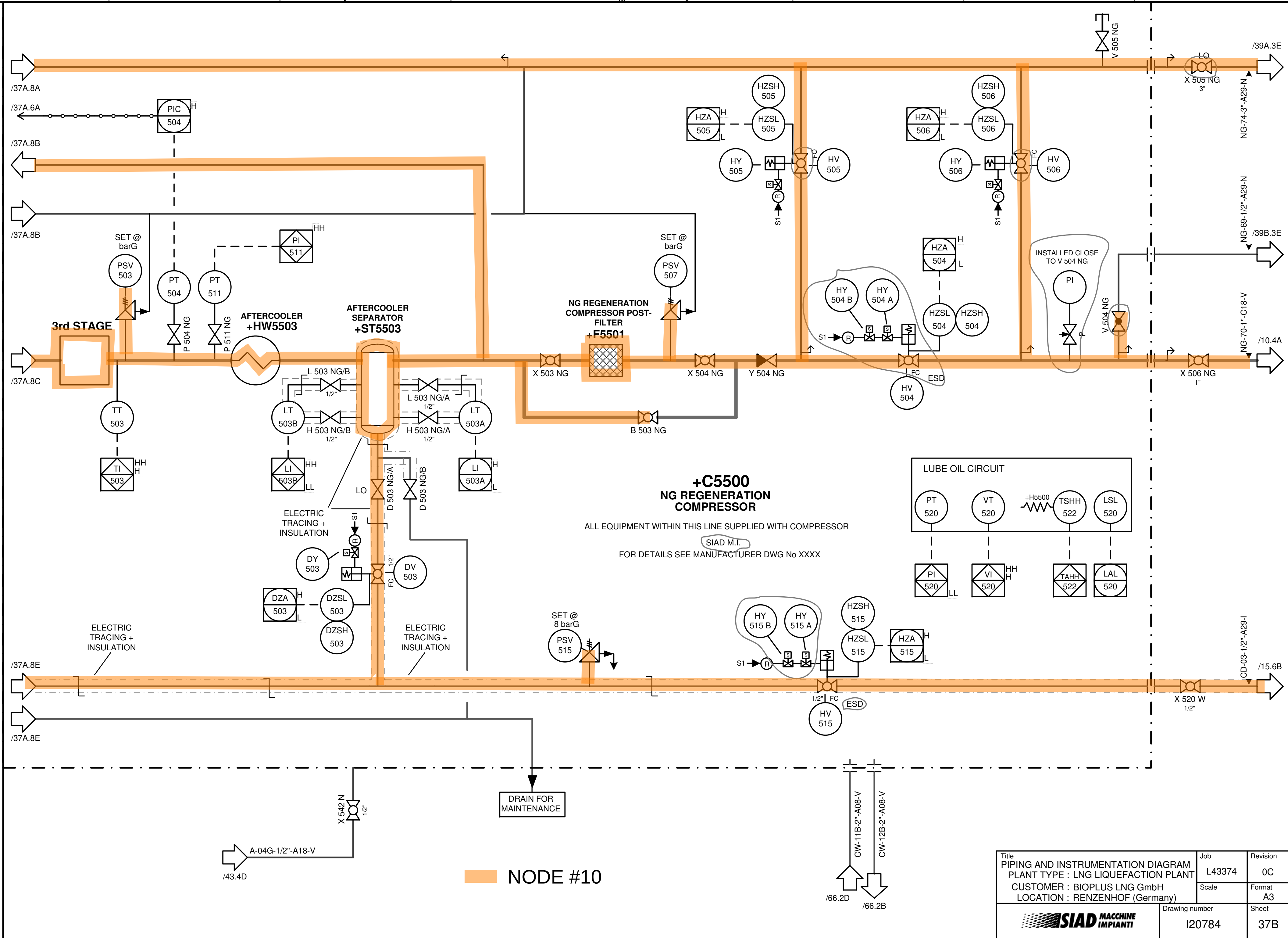
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 36



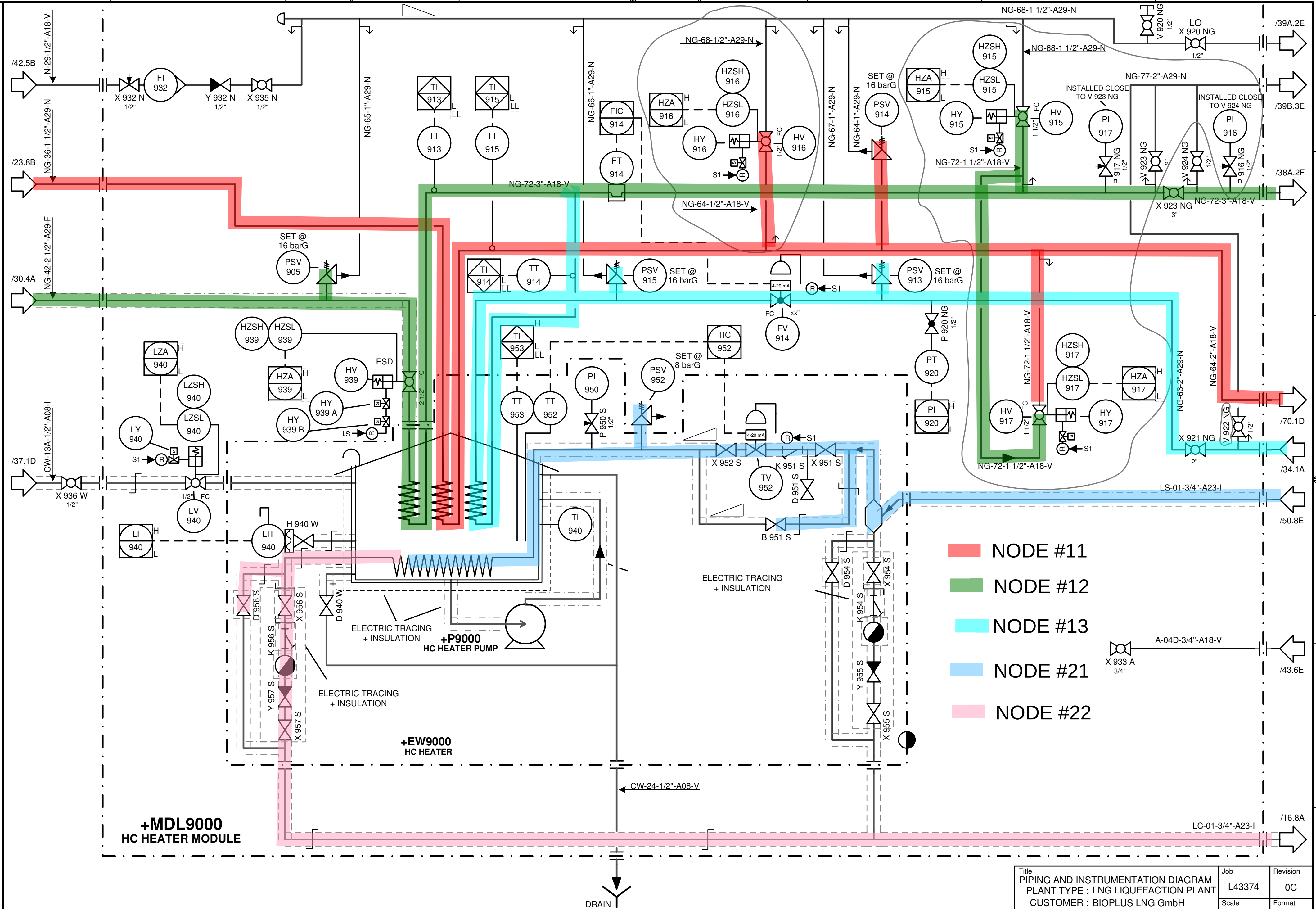
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 37



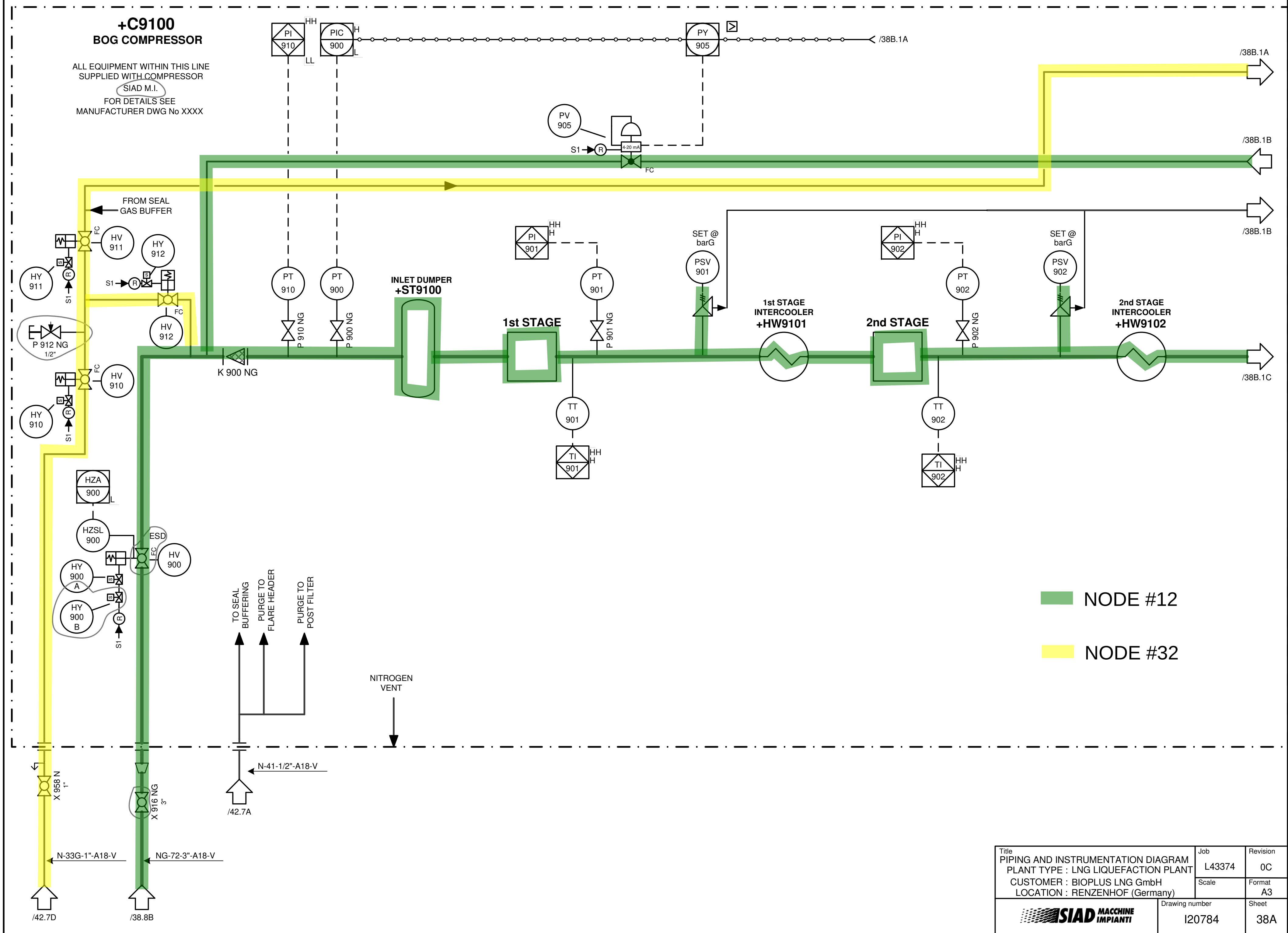
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 37A



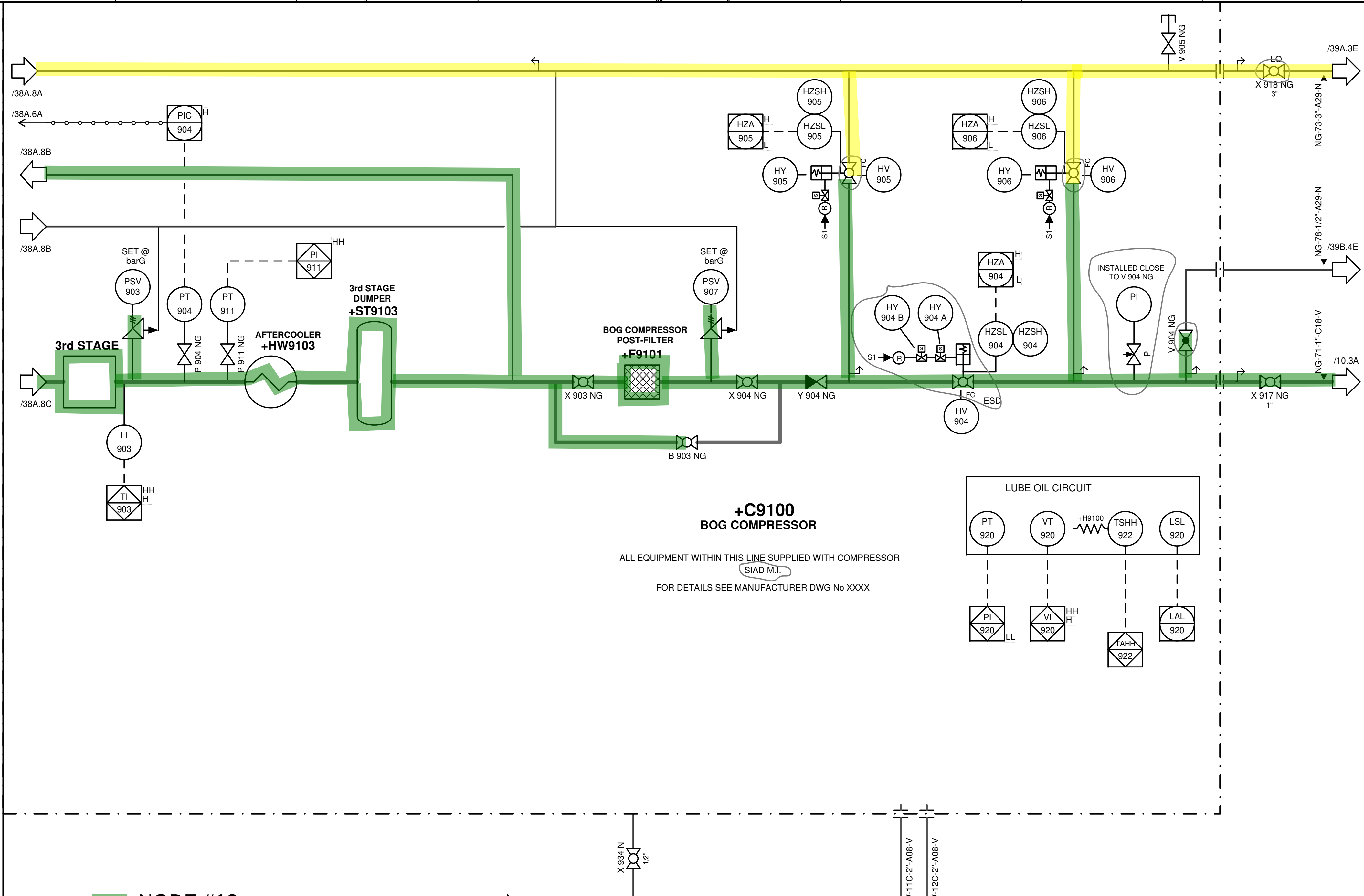
/37A.8A
/37A.6A
PIC 504
/37A.8B
/37A.8B
SET @ barG
PSV 503
PT 504
PT 511
PI 511
P 504 NG
P 511 NG
3rd STAGE
AFTERCOOLER +HW5503
AFTERCOOLER SEPARATOR +ST5503
NG REGENERATION COMPRESSOR POST-FILTER +F5501
SET @ barG
PSV 507
/37A.8C
TT 503
TI 503
L 503 NG/B 1/2"
L 503 NG/A 1/2"
H 503 NG/B 1/2"
H 503 NG/A 1/2"
LT 503B
LT 503A
LI 503B
LI 503A
LO
D 503 NG/A
D 503 NG/B
ELECTRIC TRACING + INSULATION
S1
DY 503
DV 503
FC
DZA 503
DZSL 503
DZSH 503
X 503 NG
B 503 NG
X 504 NG
Y 504 NG
HZSH 505
HZA 505
HZSL 505
HY 505
HV 505
FO
HZSH 506
HZA 506
HZSL 506
HY 506
HV 506
FC
HZA 504
HY 504 B
HY 504 A
HZSL 504
HZSH 504
S1
HV 504
ESD
INSTALLED CLOSE TO V 504 NG
PI
V 504 NG
V 505 NG
LO
X 505 NG 3"
/39A.3E
NG-74-3"-A29-N
NG-69-1/2"-A29-N
/39B.3E
NG-70-1"-C18-V
/10.4A
X 506 NG 1"
+C5500
NG REGENERATION COMPRESSOR
ALL EQUIPMENT WITHIN THIS LINE SUPPLIED WITH COMPRESSOR
SIAD M.I.
FOR DETAILS SEE MANUFACTURER DWG No XXXX
LUBE OIL CIRCUIT
PT 520
VT 520
+H5500
TSHH 522
LSL 520
PI 520
VI 520
TAHH 522
LAL 520
ELECTRIC TRACING + INSULATION
ELECTRIC TRACING + INSULATION
/37A.8E
SET @ 8 barG
PSV 515
HY 515 B
HY 515 A
HZSH 515
HZSL 515
HZA 515
S1
HV 515
1/2" FC
ESD
CD-03-1/2"-A29-I
/15.6B
X 520 W 1/2"
/37A.8E
DRAIN FOR MAINTENANCE
X 542 N 1/2"
A-04G-1/2"-A18-V
/43.4D
CW-11B-2"-A08-V
CW-12B-2"-A08-V
/66.2D
/66.2B
NODE #10
Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job L43374
Revision 0C
Scale
Format A3
Drawing number I20784
Sheet 37B
SIAD MACCHINE IMPIANTI



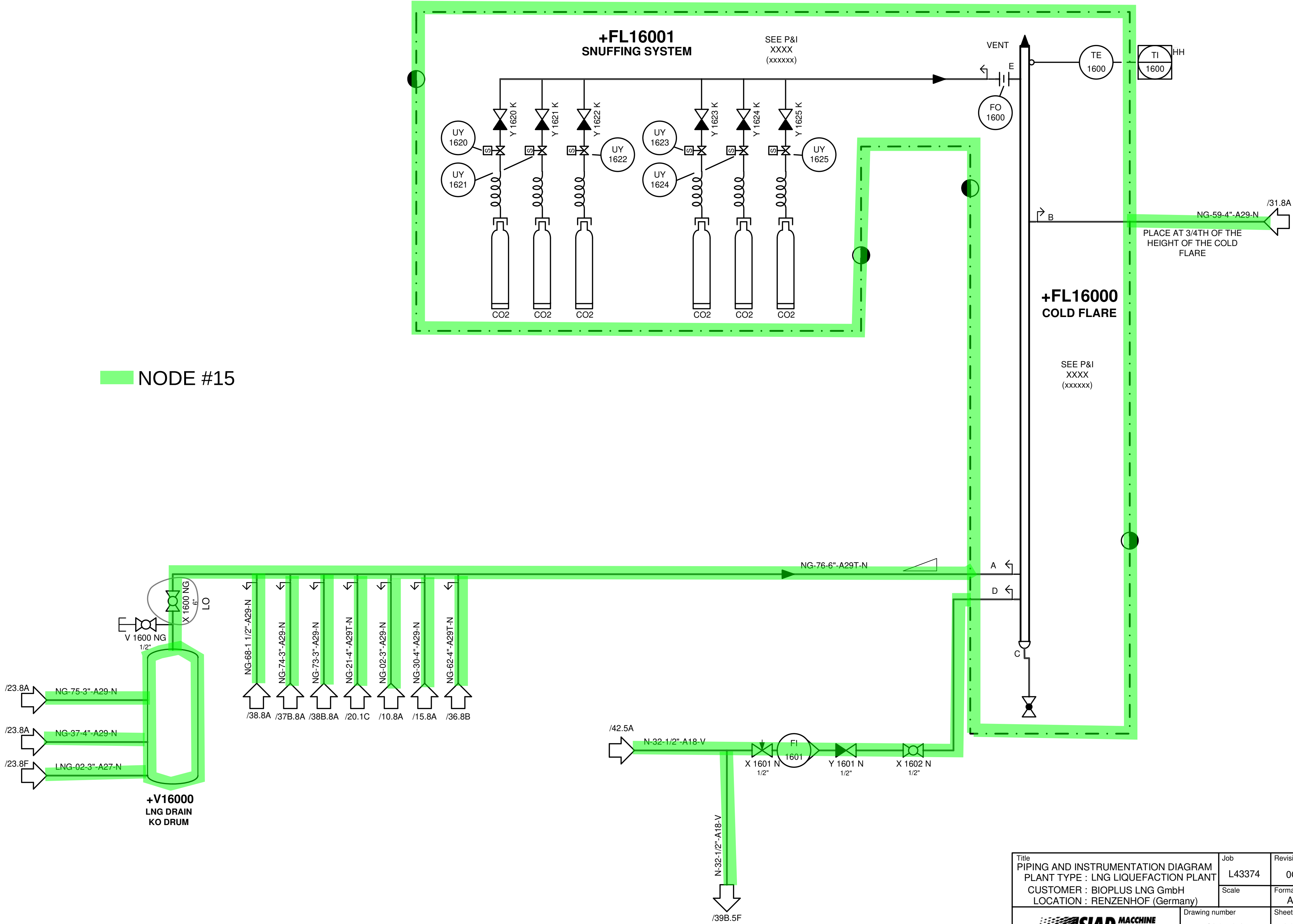
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 38



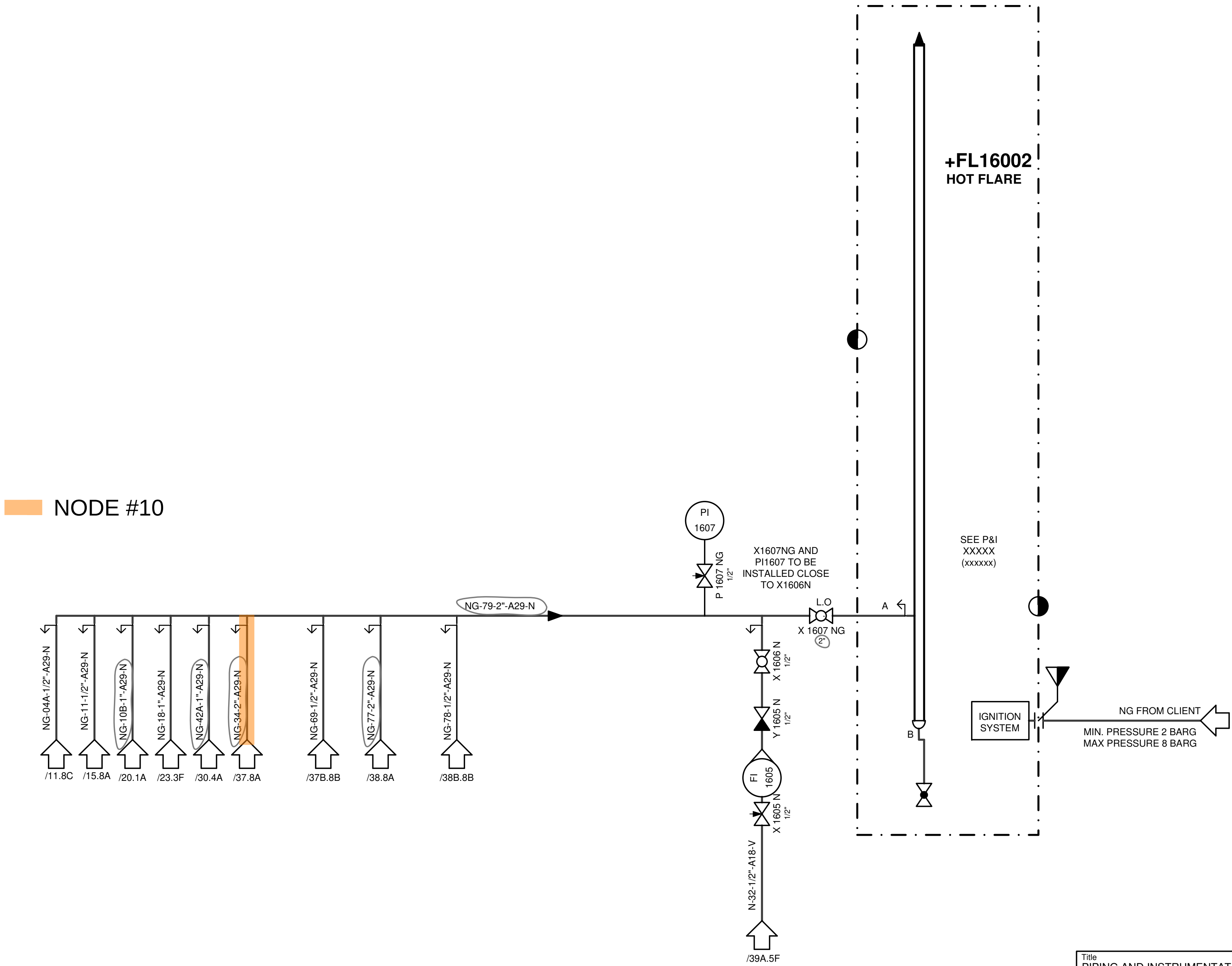
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 38A



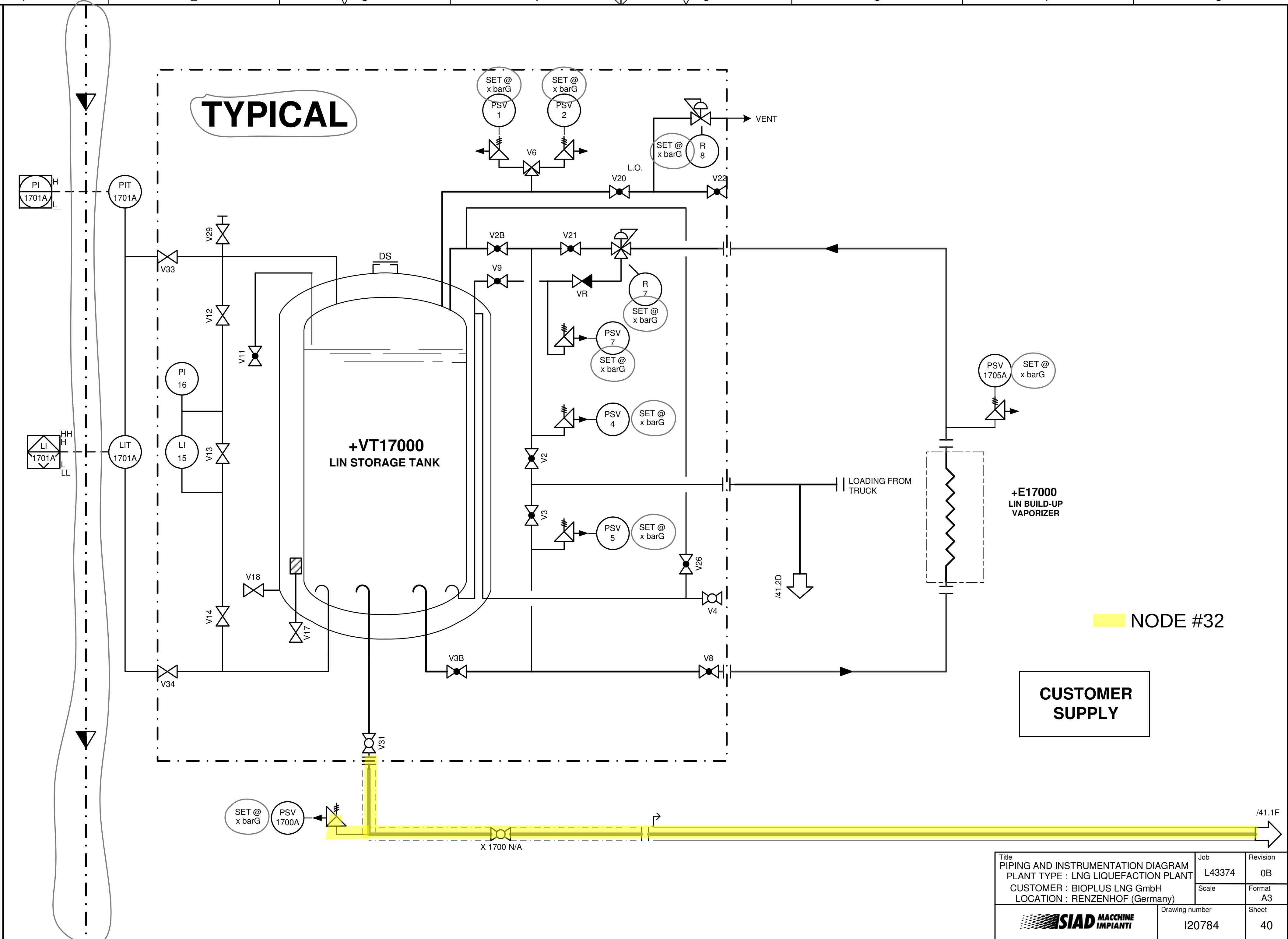
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 38B



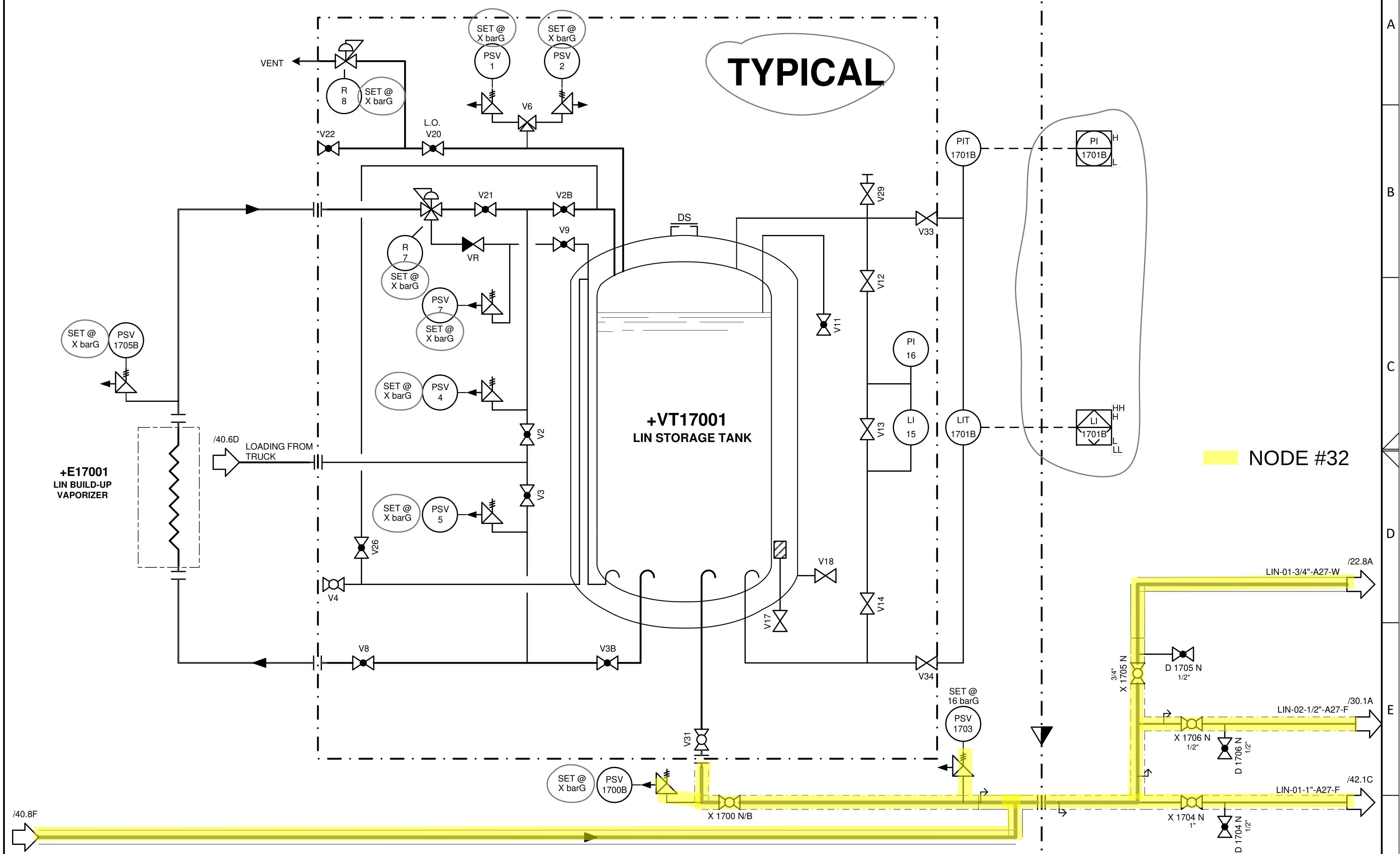
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 39A



Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0C
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 39B

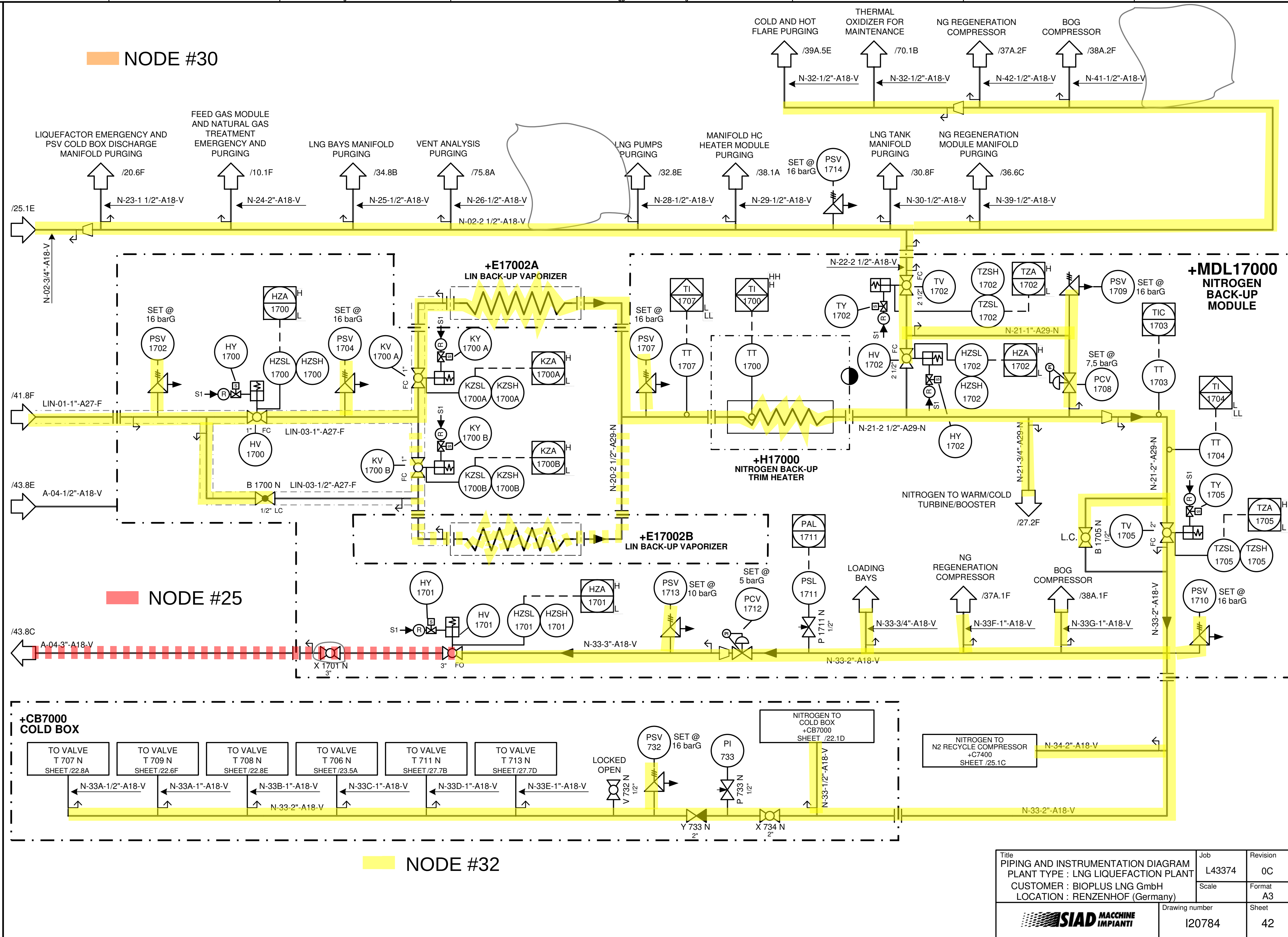


Title PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job L43374	Revision 0B
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 40

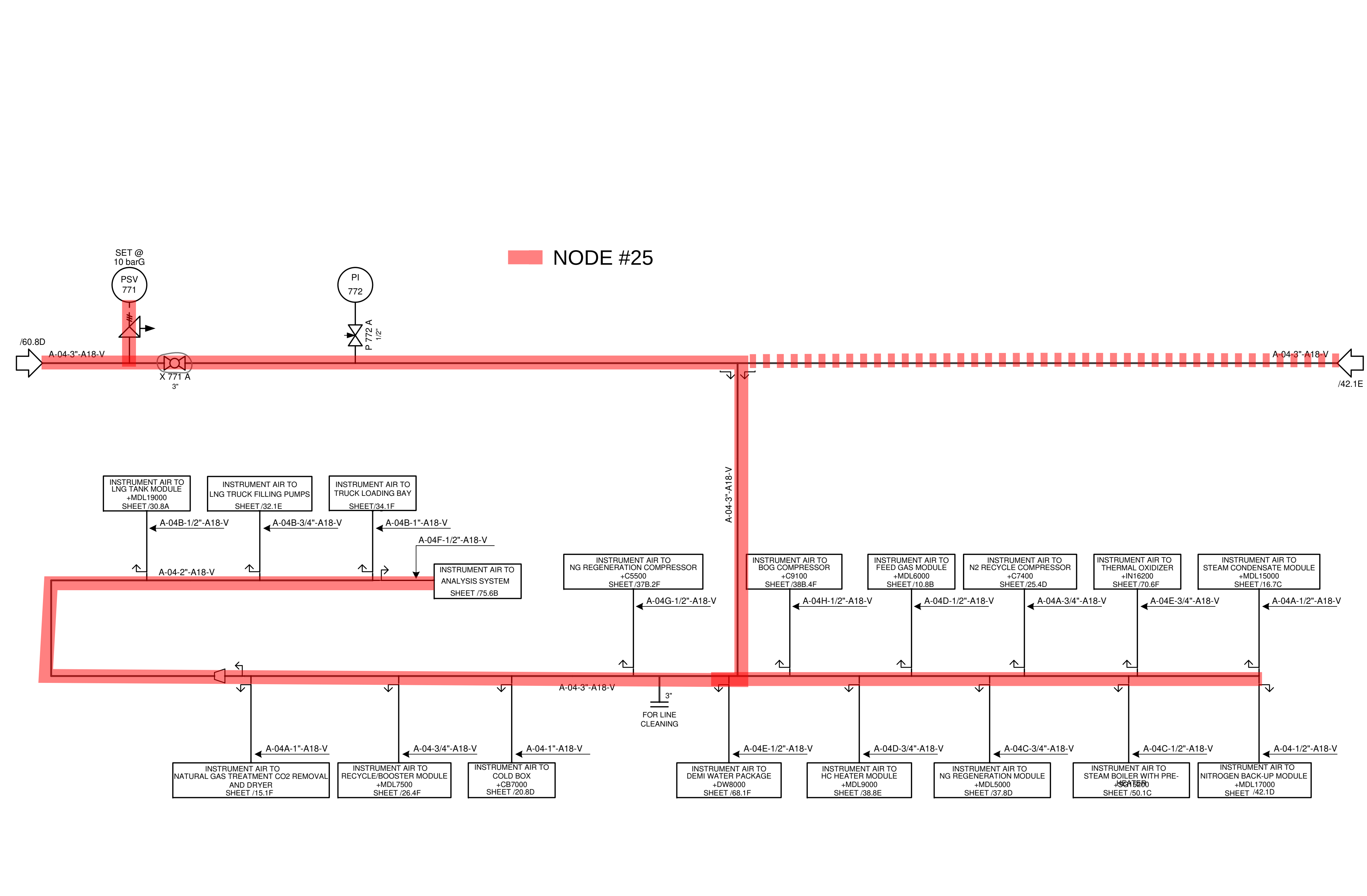


CUSTOMER SUPPLY

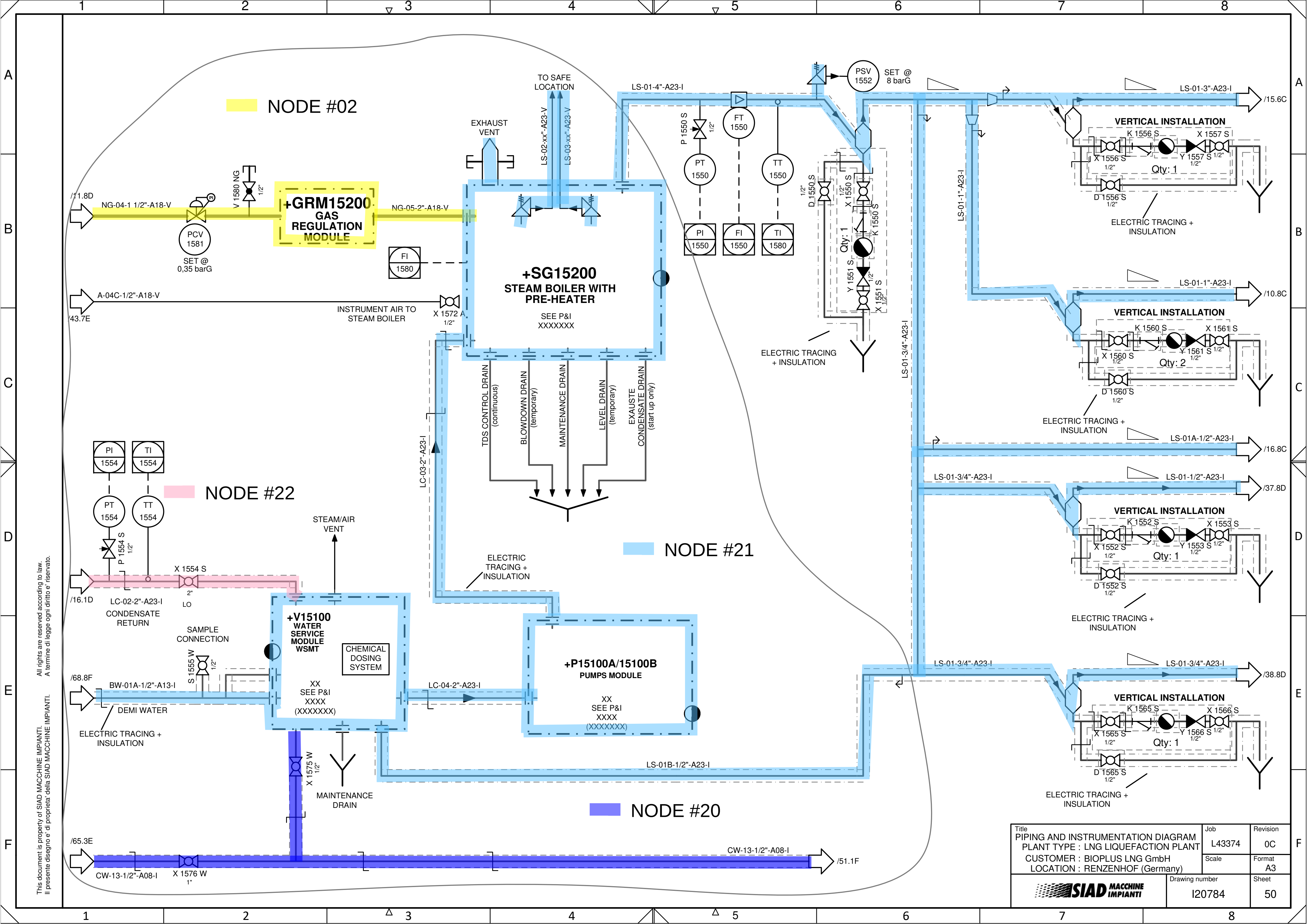
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0B
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 41



NODE #30
NODE #25
NODE #32
COLD AND HOT FLARE PURGING
THERMAL OXIDIZER FOR MAINTENANCE
NG REGENERATION COMPRESSOR
BOG COMPRESSOR
/39A.5E
/70.1B
/37A.2F
/38A.2F
N-32-1/2"-A18-V
N-42-1/2"-A18-V
N-41-1/2"-A18-V
LIQUEFACTOR EMERGENCY AND PSV COLD BOX DISCHARGE MANIFOLD PURGING
FEED GAS MODULE AND NATURAL GAS TREATMENT EMERGENCY AND PURGING
LNG BAYS MANIFOLD PURGING
VENT ANALYSIS PURGING
LNG PUMPS PURGING
MANIFOLD HC HEATER MODULE PURGING
LNG TANK MANIFOLD PURGING
NG REGENERATION MODULE MANIFOLD PURGING
/20.6F
/10.1F
/34.8B
/75.8A
/32.8E
/38.1A
/30.8F
/36.6C
/25.1E
N-23-1 1/2"-A18-V
N-24-2"-A18-V
N-25-1/2"-A18-V
N-26-1/2"-A18-V
N-02-2 1/2"-A18-V
N-28-1/2"-A18-V
N-29-1/2"-A18-V
N-30-1/2"-A18-V
N-39-1/2"-A18-V
N-02-3/4"-A18-V
SET @ 16 barG
PSV 1714
N-22-2 1/2"-A18-V
+E17002A
LIN BACK-UP VAPORIZER
+MDL17000
NITROGEN BACK-UP MODULE
PSV 1702
HY 1700
HZA 1700
HZSL 1700
HZSH 1700
PSV 1704
KV 1700 A
KY 1700 A
KZA 1700A
KZSL 1700A
KZSH 1700A
PSV 1707
TI 1707
TT 1707
TI 1700
TT 1700
TY 1702
TV 1702
TZSH 1702
TZA 1702
TZSL 1702
PSV 1709
SET @ 16 barG
TIC 1703
TT 1703
SET @ 7,5 barG
PCV 1708
HV 1702
HZSL 1702
HZA 1702
HZSH 1702
N-21-1"-A29-N
/41.8F
LIN-01-1"-A27-F
LIN-03-1"-A27-F
HV 1700
KV 1700 B
KY 1700 B
KZA 1700B
KZSL 1700B
KZSH 1700B
B 1700 N
LIN-03-1/2"-A27-F
1/2" LC
/43.8E
A-04-1/2"-A18-V
N-20-2 1/2"-A29-N
+H17000
NITROGEN BACK-UP TRIM HEATER
N-21-2 1/2"-A29-N
HY 1702
N-21-3/4"-A29-N
NITROGEN TO WARM/COLD TURBINE/BOOSTER
/27.2F
TI 1704
TT 1704
N-21-2"-A29-N
TY 1705
TZA 1705
TV 1705
L.C.
B 1705 N
TZSL 1705
TZSH 1705
+E17002B
LIN BACK-UP VAPORIZER
PAL 1711
PSL 1711
P 1711 N
SET @ 5 barG
PCV 1712
PSV 1713
SET @ 10 barG
LOADING BAYS
NG REGENERATION COMPRESSOR
BOG COMPRESSOR
/37A.1F
/38A.1F
N-33-3/4"-A18-V
N-33F-1"-A18-V
N-33G-1"-A18-V
N-33-2"-A18-V
PSV 1710
SET @ 16 barG
HY 1701
HV 1701
HZSL 1701
HZSH 1701
HZA 1701
N-33-3"-A18-V
/43.8C
A-04-3"-A18-V
X 1701 N
3" FO
+CB7000
COLD BOX
TO VALVE T 707 N SHEET /22.8A
TO VALVE T 709 N SHEET /22.6F
TO VALVE T 708 N SHEET /22.8E
TO VALVE T 706 N SHEET /23.5A
TO VALVE T 711 N SHEET /27.7B
TO VALVE T 713 N SHEET /27.7D
N-33A-1/2"-A18-V
N-33A-1"-A18-V
N-33B-1"-A18-V
N-33C-1"-A18-V
N-33D-1"-A18-V
N-33E-1"-A18-V
N-33-2"-A18-V
LOCKED OPEN
V 732 N
PSV 732
SET @ 16 barG
PI 733
P 733 N
Y 733 N
X 734 N
NITROGEN TO COLD BOX +CB7000 SHEET /22.1D
N-33-1/2"-A18-V
NITROGEN TO N2 RECYCLE COMPRESSOR +C7400 SHEET /25.1C
N-34-2"-A18-V
Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job L43374
Revision 0C
Scale
Format A3
Drawing number I20784
Sheet 42
SIAD MACCHINE IMPIANTI



Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 43


NODE #02
NODE #22
NODE #21
NODE #20
+GRM15200
GAS REGULATION MODULE
+SG15200
STEAM BOILER WITH PRE-HEATER
SEE P&I
XXXXXXX
+V15100
WATER SERVICE MODULE WSMT
CHEMICAL DOSING SYSTEM
XX
SEE P&I
XXXX
(XXXXXXX)
+P15100A/15100B
PUMPS MODULE
XX
SEE P&I
XXXX
(XXXXXXX)
/11.8D
NG-04-1 1/2"-A18-V
PCV 1581
SET @ 0,35 barG
V 1580 NG
1/2"
NG-05-2"-A18-V
FI 1580
A-04C-1/2"-A18-V
/43.7E
INSTRUMENT AIR TO STEAM BOILER
X 1572 A
1/2"
EXHAUST VENT
TO SAFE LOCATION
LS-02-xx"-A23-V
LS-03-xx"-A23-V
TDS CONTROL DRAIN (continuous)
BLOWDOWN DRAIN (temporary)
MAINTENANCE DRAIN
LEVEL DRAIN (temporary)
EXAUSTE CONDENSATE DRAIN (start up only)
LC-03-2"-A23-I
ELECTRIC TRACING + INSULATION
PI 1554
TI 1554
PT 1554
TT 1554
P 1554 S
1/2"
X 1554 S
2"
LO
/16.1D
LC-02-2"-A23-I
CONDENSATE RETURN
STEAM/AIR VENT
SAMPLE CONNECTION
S 1555 W
1/2"
/68.8F
BW-01A-1/2"-A13-I
DEMI WATER
ELECTRIC TRACING + INSULATION
LC-04-2"-A23-I
X 1575 W
1/2"
MAINTENANCE DRAIN
LS-01B-1/2"-A23-I
/65.3E
CW-13-1/2"-A08-I
X 1576 W
1"
CW-13-1/2"-A08-I
/51.1F
LS-01-4"-A23-I
P 1550 S
1/2"
PT 1550
FT 1550
TT 1550
PI 1550
FI 1550
TI 1580
PSV 1552
SET @ 8 barG
D 1550 S
1/2"
X 1550 S
1/2"
K 1550 S
Qty: 1
Y 1551 S
1/2"
X 1551 S
1/2"
ELECTRIC TRACING + INSULATION
LS-01-1"-A23-I
LS-01-3/4"-A23-I
LS-01-3"-A23-I
/15.6C
VERTICAL INSTALLATION
K 1556 S
X 1557 S
X 1556 S
1/2"
Y 1557 S
1/2"
Qty: 1
D 1556 S
1/2"
ELECTRIC TRACING + INSULATION
LS-01-1"-A23-I
/10.8C
VERTICAL INSTALLATION
K 1560 S
X 1561 S
X 1560 S
1/2"
Y 1561 S
1/2"
Qty: 2
D 1560 S
1/2"
ELECTRIC TRACING + INSULATION
LS-01A-1/2"-A23-I
/16.8C
LS-01-3/4"-A23-I
LS-01-1/2"-A23-I
/37.8D
VERTICAL INSTALLATION
K 1552 S
X 1553 S
X 1552 S
1/2"
Y 1553 S
1/2"
Qty: 1
D 1552 S
1/2"
ELECTRIC TRACING + INSULATION
LS-01-3/4"-A23-I
LS-01-3/4"-A23-I
/38.8D
VERTICAL INSTALLATION
K 1565 S
X 1566 S
X 1565 S
1/2"
Y 1566 S
1/2"
Qty: 1
D 1565 S
1/2"
ELECTRIC TRACING + INSULATION
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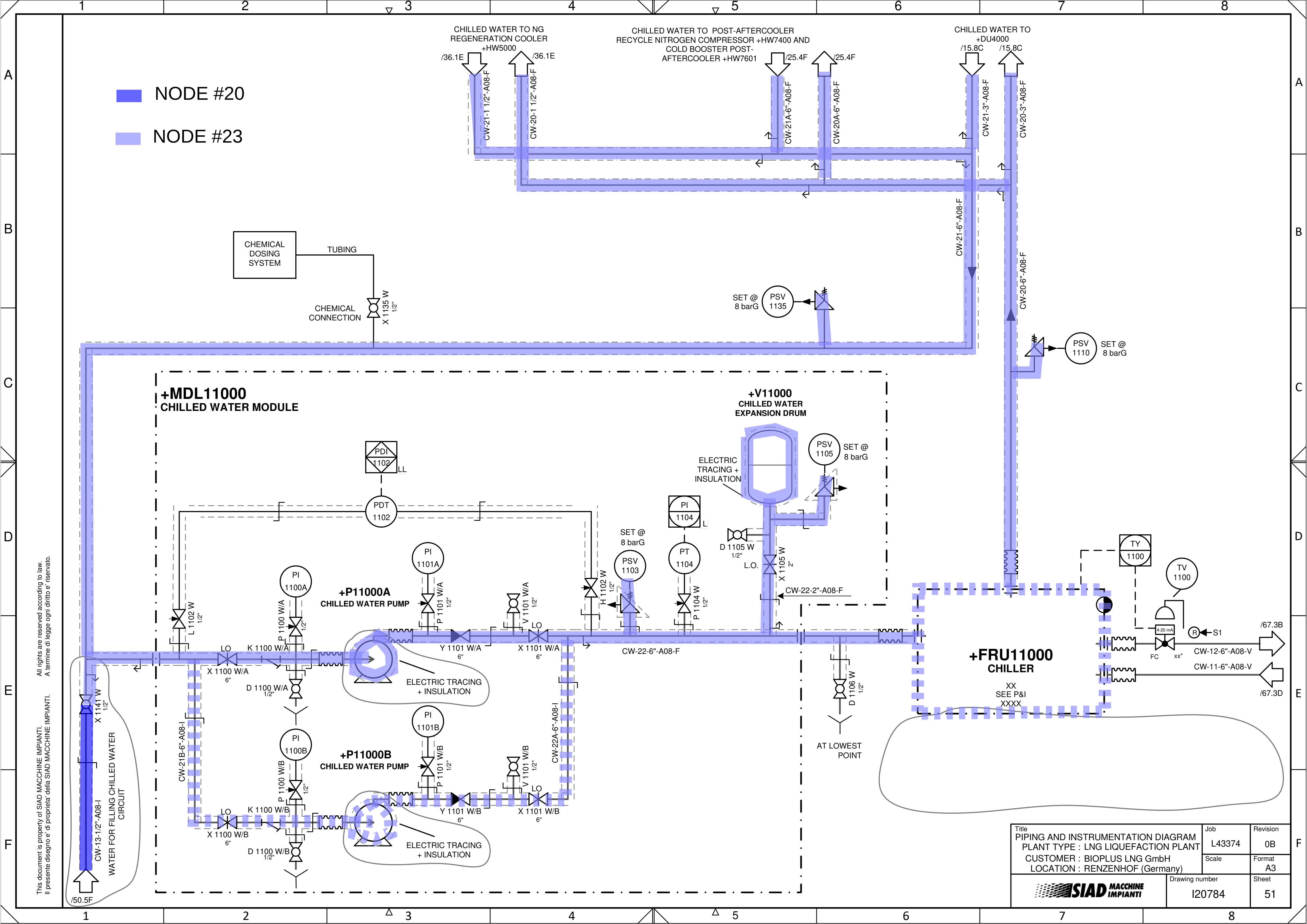
Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job
L43374
Revision
0C
Scale
Format
A3
Drawing number
I20784
Sheet
50
SIAD MACCHINE IMPIANTI



NODE #20
NODE #23
CHILLED WATER TO NG REGENERATION COOLER +HW5000
/36.1E
/36.1E
CW-21-1 1/2"-A08-F
CW-20-1 1/2"-A08-F
CHILLED WATER TO POST-AFTERCOOLER RECYCLE NITROGEN COMPRESSOR +HW7400 AND COLD BOOSTER POST-AFTERCOOLER +HW7601
/25.4F
/25.4F
CW-21A-6"-A08-F
CW-20A-6"-A08-F
CHILLED WATER TO +DU4000
/15.8C
/15.8C
CW-21-3"-A08-F
CW-20-3"-A08-F
CW-21-6"-A08-F
CW-20-6"-A08-F
CHEMICAL DOSING SYSTEM
TUBING
CHEMICAL CONNECTION
X 1135 W 1/2"
SET @ 8 barG
PSV 1135
PSV 1110
SET @ 8 barG
+MDL11000
CHILLED WATER MODULE
+V11000
CHILLED WATER EXPANSION DRUM
ELECTRIC TRACING + INSULATION
PSV 1105
SET @ 8 barG
PDI 1102 LL
PDT 1102
PI 1104 L
D 1105 W 1/2"
L.O.
X 1105 W 2"
CW-22-2"-A08-F
SET @ 8 barG
PSV 1103
PT 1104
P 1104 W 1/2"
H 1102 W 1/2"
PI 1101A
PI 1100A
+P11000A
CHILLED WATER PUMP
P 1101 W/A 1/2"
V 1101 W/A 1/2"
P 1100 W/A 1/2"
L 1102 W 1/2"
LO
K 1100 W/A
X 1100 W/A 6"
D 1100 W/A 1/2"
Y 1101 W/A 6"
LO
X 1101 W/A 6"
CW-22-6"-A08-F
ELECTRIC TRACING + INSULATION
X 1141 W 1/2"
CW-13-1/2"-A08-I
WATER FOR FILLING CHILLED WATER CIRCUIT
/50.5F
CW-21B-6"-A08-I
CW-22A-6"-A08-I
PI 1101B
PI 1100B
+P11000B
CHILLED WATER PUMP
P 1101 W/B 1/2"
V 1101 W/B 1/2"
P 1100 W/B 1/2"
LO
K 1100 W/B
X 1100 W/B 6"
D 1100 W/B 1/2"
Y 1101 W/B 6"
LO
X 1101 W/B 6"
ELECTRIC TRACING + INSULATION
D 1106 W 1/2"
AT LOWEST POINT
TY 1100
TV 1100
4-20 mA
FC
xx"
R
S1
/67.3B
CW-12-6"-A08-V
CW-11-6"-A08-V
/67.3D
+FRU11000
CHILLER
XX
SEE P&I
XXXX
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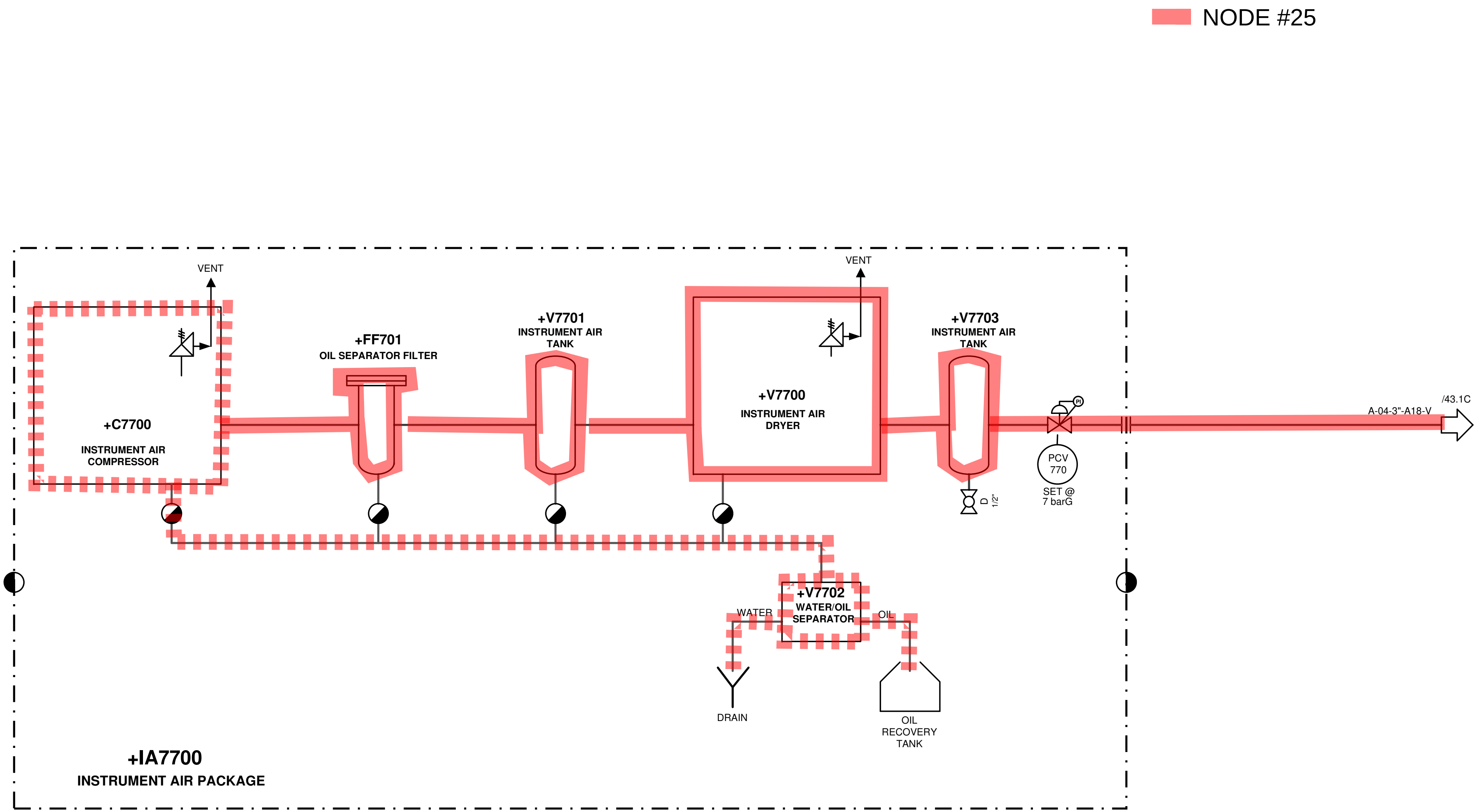
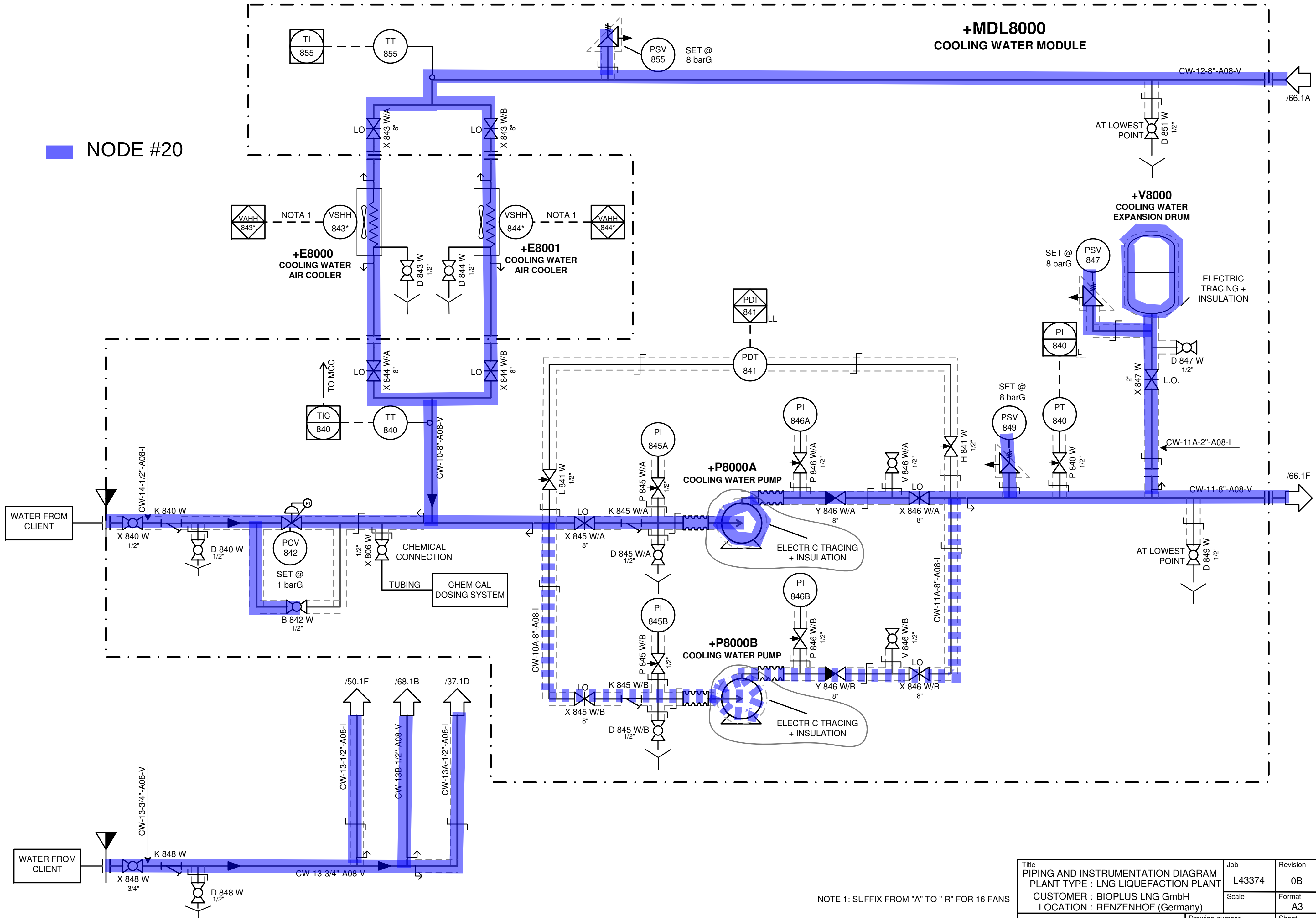
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)
Job L43374
Revision 0B
Scale
Format A3
Drawing number I20784
Sheet 51
SIAD MACCHINE IMPIANTI

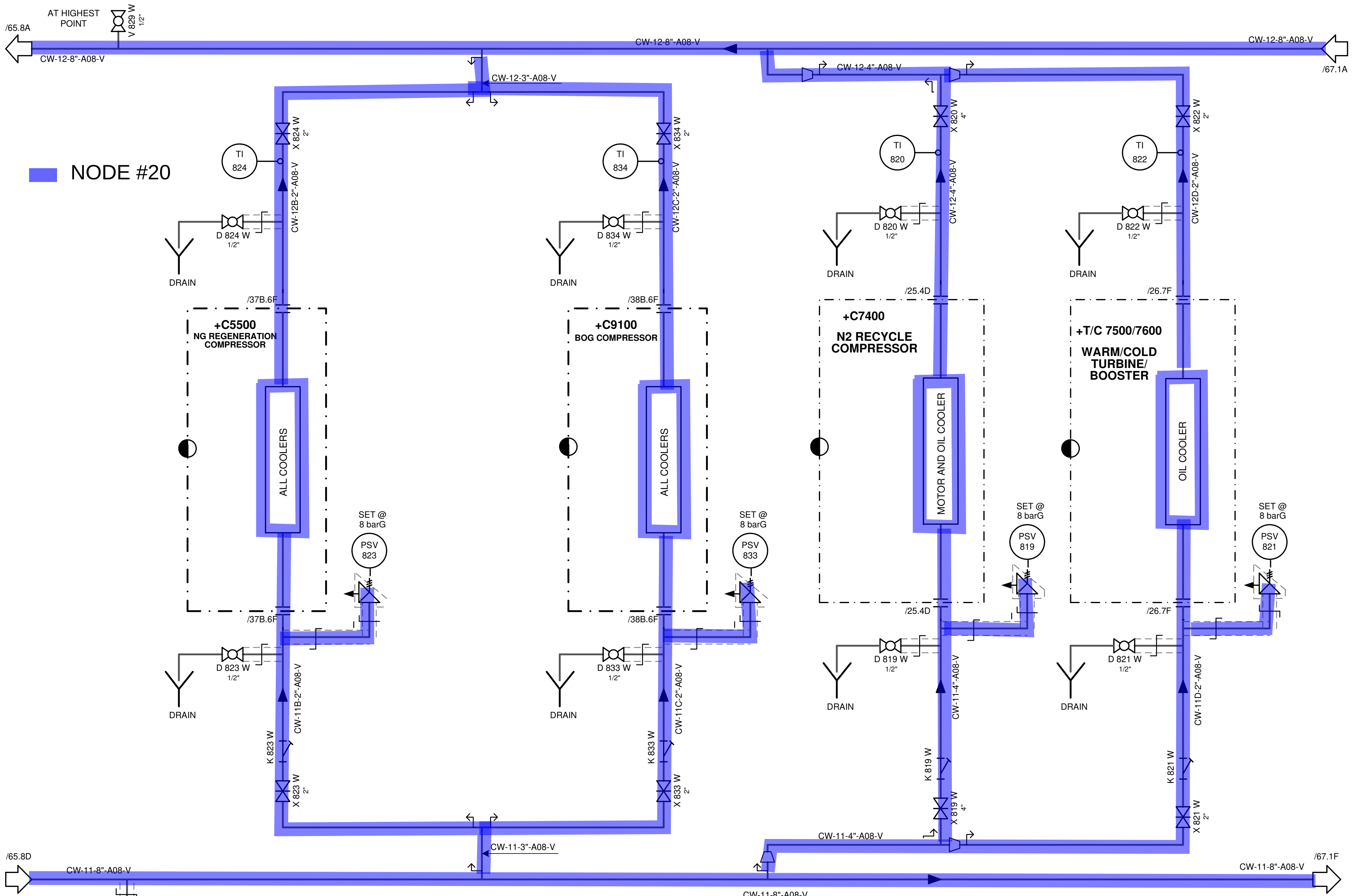


Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0A
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 60



NOTE 1: SUFFIX FROM "A" TO " R" FOR 16 FANS

Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0B
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 65

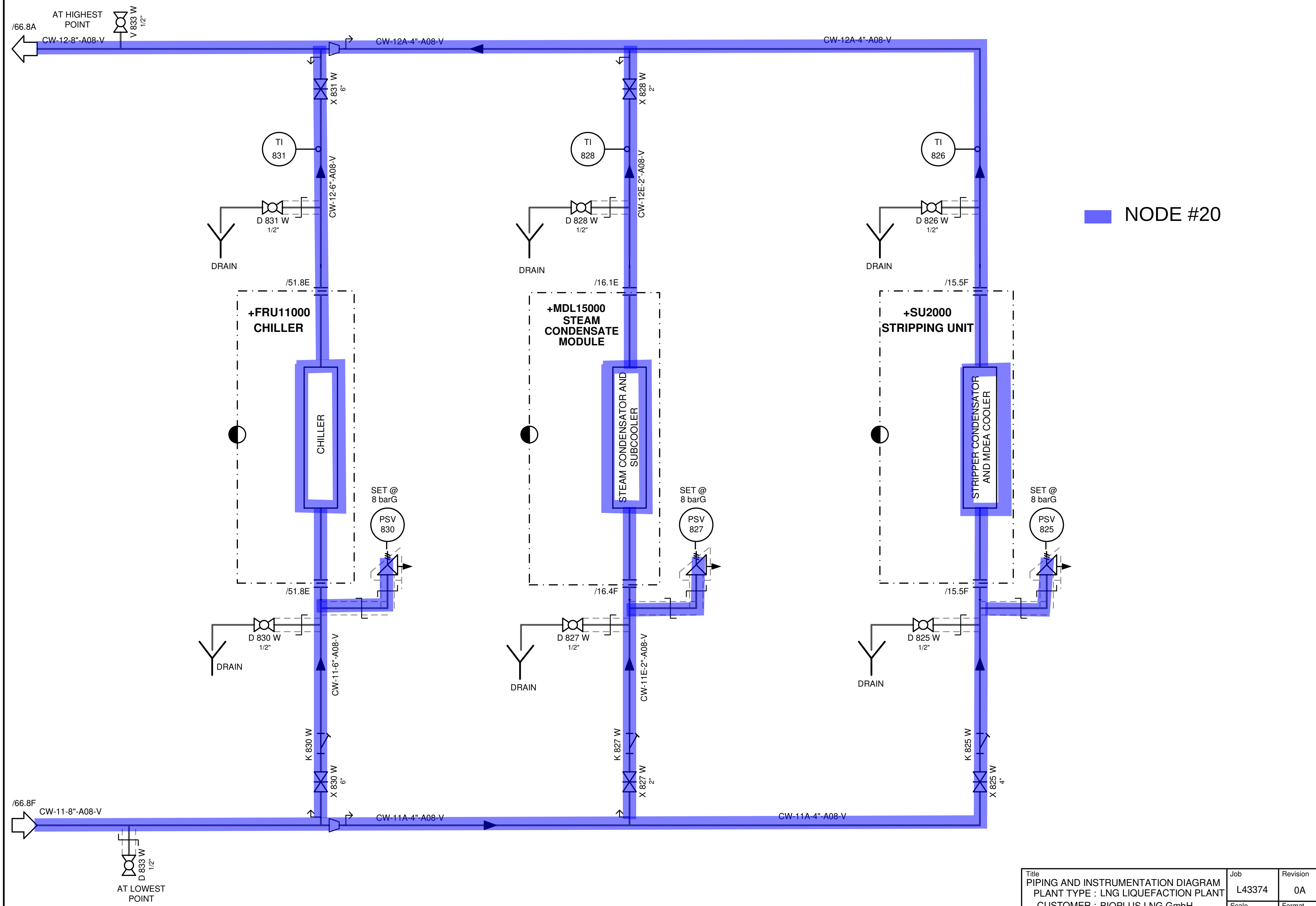


Title
PIPING AND INSTRUMENTATION DIAGRAM
PLANT TYPE : LNG LIQUEFACTION PLANT
CUSTOMER : BIOPLUS LNG GmbH
LOCATION : RENZENHOF (Germany)

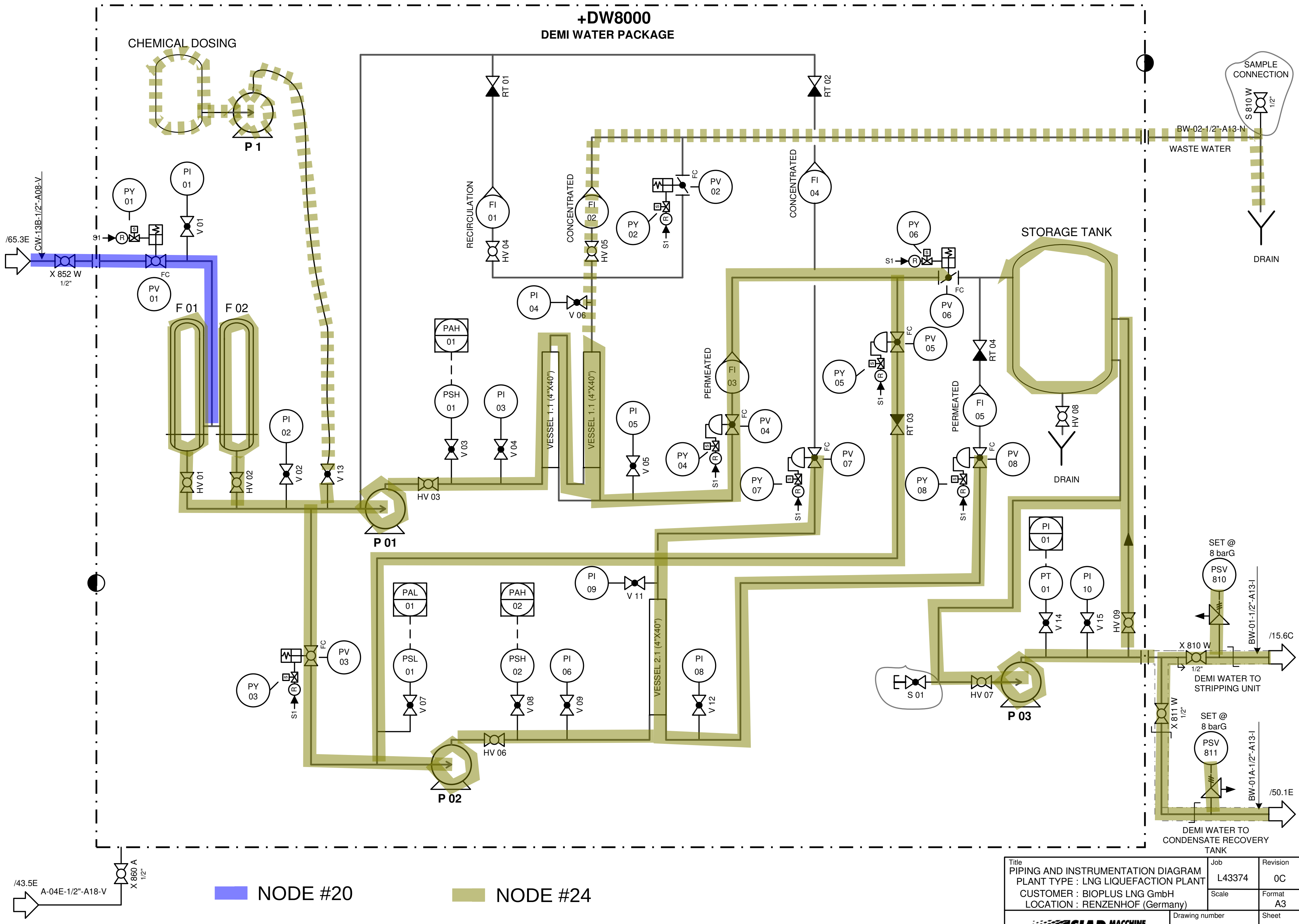
Job	Revision
L43374	0A
Scale	Format A3

SIAD MACCHINE IMPIANTI

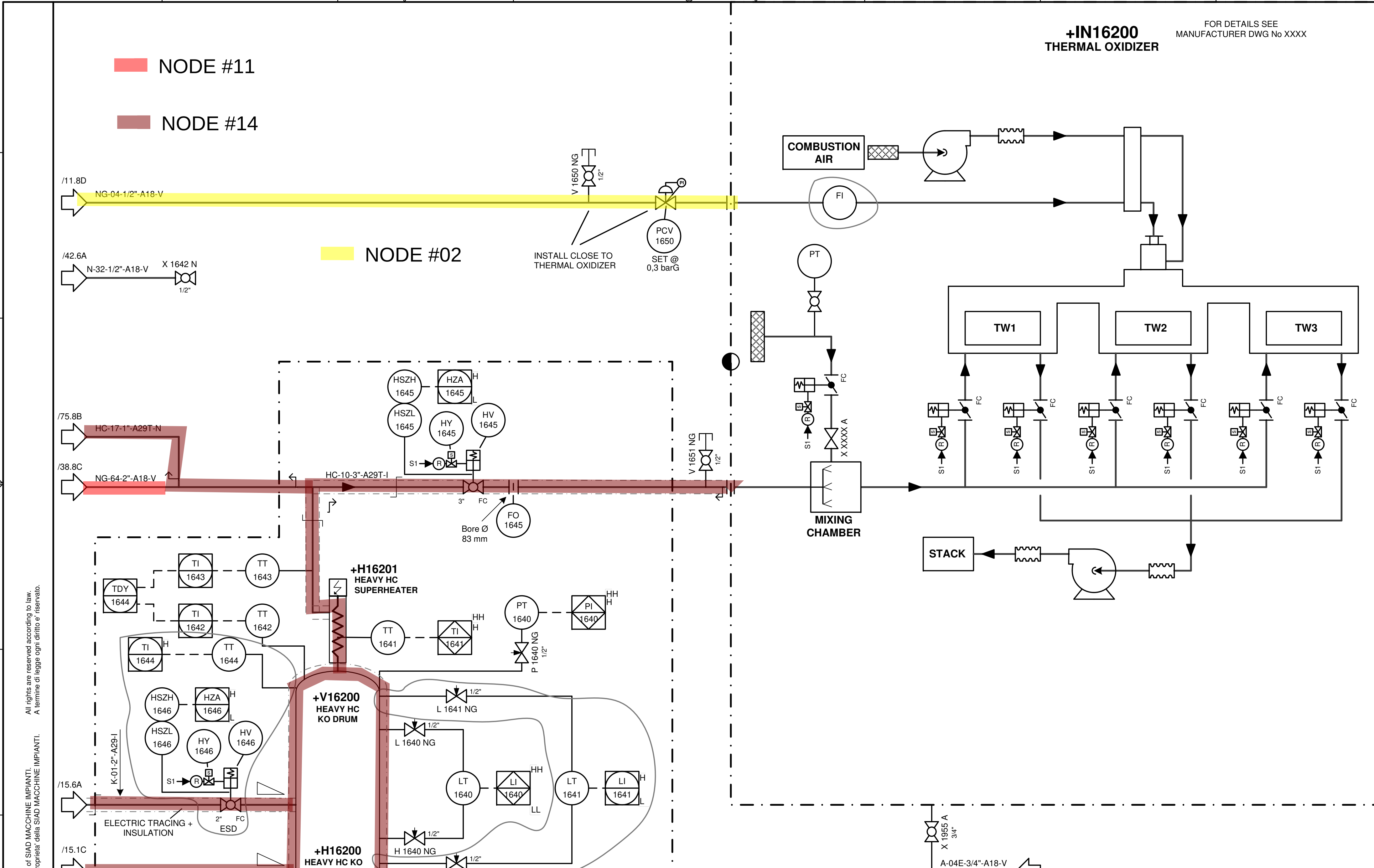
Drawing number	Sheet
I20784	66



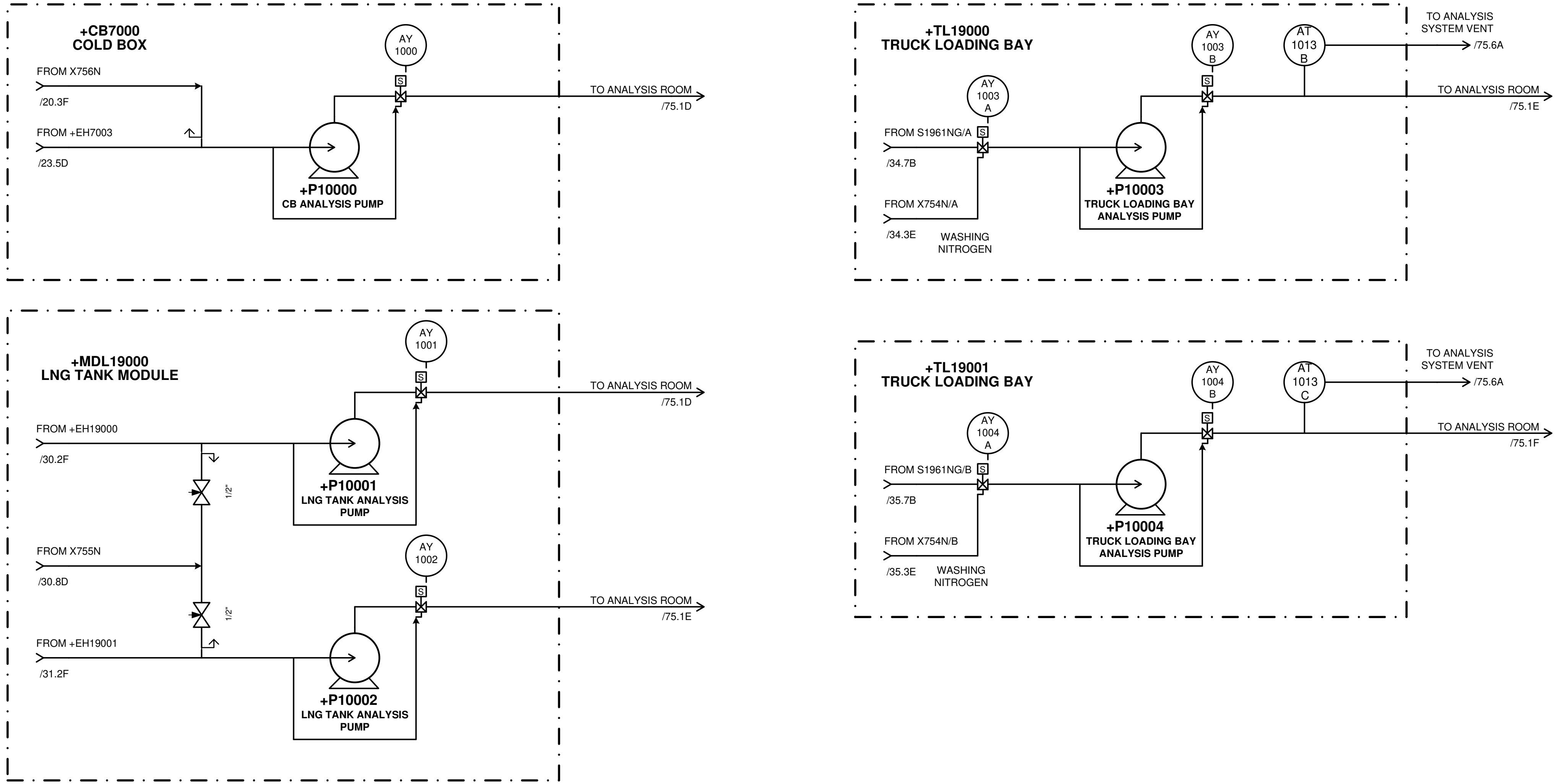
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0A
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 67



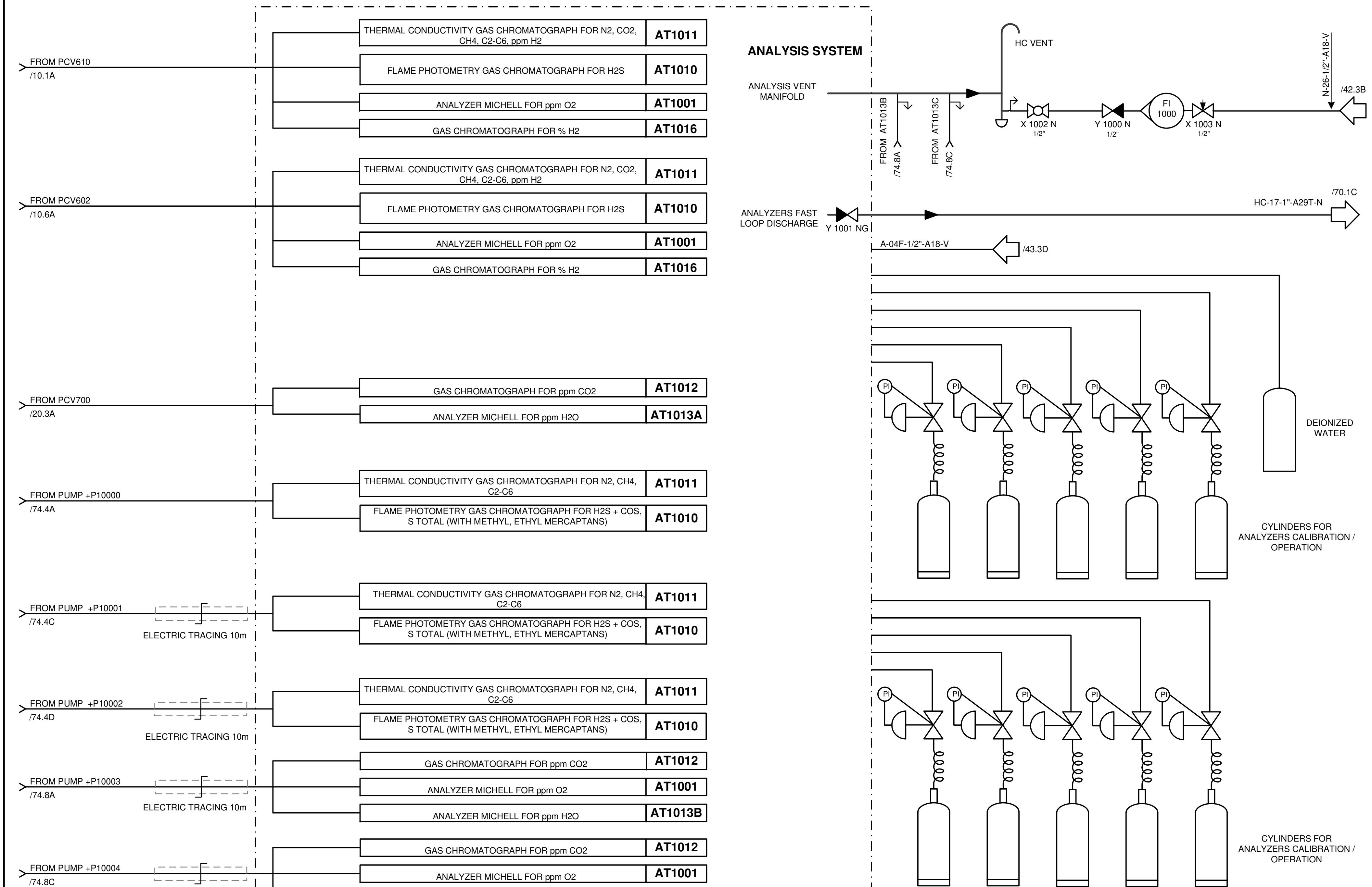
Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Job: L43374	Revision: 0C	
	Scale	Format: A3	
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 68	



Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0C
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 70

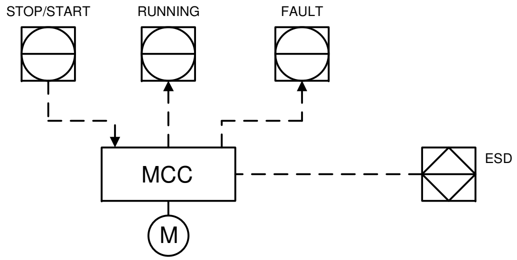


Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0A
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 74

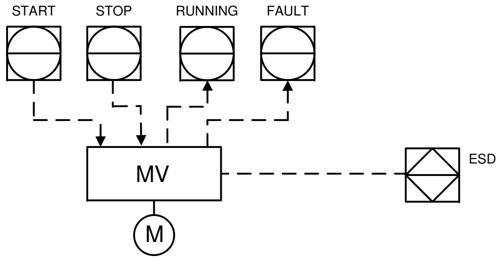


Title: PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	Job: L43374	Revision: 0A
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale:	Format: A3
SIAD MACCHINE IMPIANTI	Drawing number: I20784	Sheet: 75

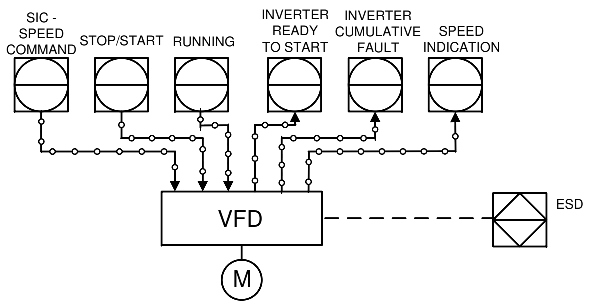
TYPE 1 - LV MOTOR TYPICAL



TYPE 2 - MV MOTOR TYPICAL

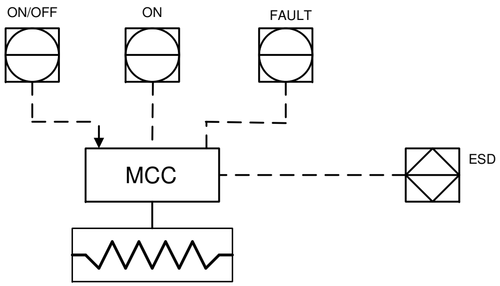


TYPE 8 - LV MOTOR UNDER VFD

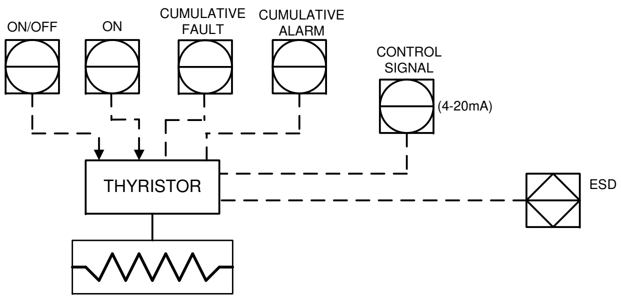


Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0A
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 80

TYPE 3 – HEATERS ON/OFF TYPICAL

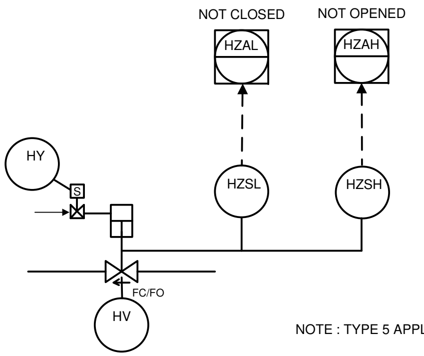


TYPE 4 – HEATERS WITH THYRISTOR TYPICAL



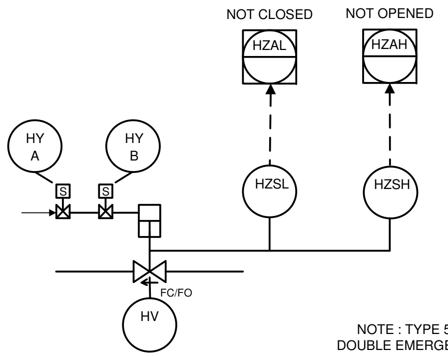
Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	L43374	0A
	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 81

TYPE 5 – ON/OFF VALVE (ESD) TYPICAL



NOTE : TYPE 5 APPLICABLE TO ESD VALVES WITH EMERGENCY TRIP ONLY

TYPE 5A – ON/OFF VALVE (ESD) TYPICAL



NOTE : TYPE 5A APPLICABLE TO ESD VALVES THAT HAVE DOUBLE EMERGENCY AND PROCESS TRIP (SAFETY FUNCTION)

Title	Job	Revision
PIPING AND INSTRUMENTATION DIAGRAM PLANT TYPE : LNG LIQUEFACTION PLANT	L43374	0A
CUSTOMER : BIOPLUS LNG GmbH LOCATION : RENZENHOF (Germany)	Scale	Format A3
SIAD MACCHINE IMPIANTI	Drawing number I20784	Sheet 82

ATTACHMENT 3

HAZOP Worksheet

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Location: Renzenhof, Germany
Facility: LNG liquefaction plant
PHA Method: HAZOP
PHA Type: Initial

Process:

File Description:

Date:

Process Description:

Chemicals:

Purpose:

Scope:

Objectives:

Project Notes:

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (00) General issues
Intention:
Notes:
Drawings:
Parameter: Flow
Equipment:

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect	1. Misdirect Flow	1.1. Inadvertent opening of vent valve on NG circuit to hot flare	1.1.1. Potential overpressurization of hot flare header		1. Mode of operation of hot flare and potential overpressurization scenario due to inadvertent opening of manual vent valves to be investigated once design of hot flare will be finalized (e. g. increasing DP of hot flare header, etc...)	SIAD MI / OGE	
			1.1.2. Possible unexpected routing of gas to hot flare when not in operation with possible environmental concern/ complains from authorities		2. Appropriate isolation philosophy to be investigated for drains and vents on LNG/NG high pressure vents and drains to hot flare used for maintenance purposes only	SIAD MI / OGE	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Flow

Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	2. No/less Flow	2.1. Loss of natural gas from BL (any causes)	2.1.1. No impact on this node				
			2.1.2. Loss of natural gas to downstream section (See Node #01B and #02)	2.1.2.1. PAL/PALL-B40622 and operator response			
			2.1.3. Loss of natural gas to ground flare pilot and consequent delay in maintenance operation (ground flare is used for maintenance only)				
			2.1.4. Loss of natural gas to building heating system				
		2.2. Plugging of filter F-B41	2.2.1. According to composition of natural gas, significant plugging of the filter is not expected. In case of plugging, expected consequence is slight increase of differential pressure over time with potential minor operational upset	2.2.1.1. PDAH/AHH-B41211			
		2.3. Unexpected closure of SSV-B41520/41530 or PCV-B41540 or any other valve in the line	2.3.1. No impact on mechanical integrity of new piping according to design criteria (85 barg vs 67.5 barg)				
			2.3.2. Loss of natural gas to downstream section (See Node #01B and #02)	2.3.2.1. PAL/PALL-B40622 and operator response			
			2.3.3. No impact on existing natural gas distribution network				

Worksheet

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Flow Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	3. More Flow	3.1. Higher demand rate from downstream unit	3.1.1. Possible lower temperature of natural gas at W-B41 outlet and potential operational upset with no safety concern	3.1.1.1. TAL/TALL-B40621 and operator response			
Reverse	4. Reverse Flow	4.1. No credible causes identified					
Misdirect	5. Misdirect Flow	5.1. Stand-by PCV passing/open	5.1.1. No impact on metering since stand-by metering system is normally isolated by manual block valves 5.1.2. See pressure more for wide opening of PCV-B41540/B42540				

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Temperature Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	6. Lower Temperature	6.1. Refer to More Flow in this node					
		6.2. Failure of heater W-B41 or failure of relevant temperature control system (TT-B40621)	6.2.1. Lower temperature of natural gas at the outlet of fiscal metering station (estimated -2 °C instead of 10°C) with no impact on mechanical integrity of piping and potential operational upset on downstream sections.		3. Ensure that signal from TT-B41320 and TT-B42320 are reported to DCS including high and low temperature alarm	OGE (TPG)	

Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Temperature — Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	6. Lower Temperature (cont.)	6.2. Failure of heater W-B41 or failure of relevant temperature control system (TT-B40621) (cont.)	6.2.2. Condensation is not expected in this case according to natural gas dew point (approximately -8°C)				
		6.3. Low ambient temperature	6.3.1. No impact during normal operation if heater W-B41 is working properly. Lower temperature of natural gas. Significant condensation is not expected in this case.	6.3.1.1. TAL/TALL-B40621 and operator response (Stand-by heater available) 6.3.1.2. Metering station located inside container			
More	7. Higher Temperature	7.1. No causes identified for natural gas supply from distribution network					
		7.2. Higher heat input from heater W-B41 due to failure of relevant temperature control system (TT-B40621)	7.2.1. Increase of natural gas temperature and potential overheating of downstream piping (DT=80°C) with potential mechanical damage and loss of containment (possible fire/explosion)	7.2.1.1. Internal independent high high temperature interlock provided for heater W-B41 (Minimum requirement included on data sheet for vendor)	4. Ensure provision for internal independent high high temperature interlock provided for heater W-B41 to protect heater itself and downstream piping from overheating scenario	OGE (TPG)	
			7.2.2. Possible damage to heater elements due to overheating (economical losses)	7.2.2.1. Internal independent high high temperature interlock provided for heater W-B41 (Minimum requirement included on data sheet for vendor)	:See 4		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Pressure

Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	8. Lower Pressure	8.1. Refer to No/Less flow in this node					
More	9. Higher Pressure	9.1. No cause identified from distribution network					
		9.2. Refer to No/Less flow in this node	:				SBV-B40303 is addressed to relief gas protecting piping and prevent leading to intervention of shut-off valve SSVs in case of leakage from PCV-B41540
		9.3. PCV-B41540 malfunction (fully open), including PT-B40622 malfunction	9.3.1. Pressure build-up dowstream valve PCV-B41540 up to 65 barg and potential overpressurization (DP=52 barg) with mechanical damage, loss of containment and potential for fire/explosion	9.3.1.1. SSV-B41520/B41530 (mechanical/pneumatical devices to cut off natural gas supply)	5. Ensure adequate set point for SSV-B41520/B41530 intervention to prevent opening of PSVs located on downstream piping (set at 52 barg)	OGE (TPG)	
		9.4. PCV-610 malfunction (fully open)	9.4.1. Higher pressure of natural gas routed to analyser (44 barg instead of 1 barg) with potential overpressurization of analysers (AI-1001, 1010, 1011, 1016) and associated items (DP= 0.5 barg) with mechanical damage and potential injuries to personnel		6. Ensure provision for pressure release devices to protect analysers AI-1001, 1010, 1011, 1016 and associated items in case of wide opening of pressure let down valve PCV-610/602	SIAD MI	Tubing and first valve downstream PCV-610 are rated to withstand 65 barg
		9.5. External fire	:		7. Investigate requirement for pressure relief devices for external fire case in compliance with criteria...	OGE (TPG)	

Worksheet

Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Pressure
Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	9. Higher Pressure (cont.)	9.5. External fire (cont.)	: (cont.)		...adopted for production plant		

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Level
Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	10. No/less Level	10.1. Not applicable					
More	11. Higher Level	11.1. Not applicable					

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Composition
Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	12. Different Composition	12.1. Increased content of contaminants (CO2, H2S, H2, O2, N2)	12.1.1. No impact on this node				
			12.1.2. Possible impact on liquefaction section (see relevant nodes)	12.1.2.1. Online analysers AI-1001, 1010, 1011, 1016 including high concentration alarms			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Intention: OP upstream = 55 barg (normal operating), 65 barg (maximum operating), OP downstream = 43 barg, DP = 67.5 barg
OT upstream W-B41 = 10°C
Notes:
Drawings: I20784 Sh 10
Parameter: Services / Utilities
Equipment: F-B41/2, W-B41/2

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	13. No Services / Utilities	13.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Flow

Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	14. No/less Flow (NG feed to TW1002)	14.1. Unexpected closure of HV-600 or HV-105	14.1.1. Blocked outlet for upstream section (See No/Less flow in Node #01A)				
			14.1.2. Pressure build-up overtime dowstream valve PCV-B41540 up to 65 barg and potential overpressurization (DP=52 barg) with mechanical damage, loss of containment and potential for fire/explosion	14.1.2.1. Discrepancy alarm provide for HVs 14.1.2.2. PAH/PAHH-B40622 and operator response 14.1.2.3. SSV-B41520/B41530 (mechanical/pneumatical devices to cut off natural gas supply)			
			14.1.3. No impact on equipment in this node				
			14.1.4. Loss of natural gas to downstream sections (see relevant nodes)				
		14.2. Signficant plugging of mercury trap is not expected according to gas composition					
		14.3. Possible plugging of dust filter	14.3.1. Increased DP accross F1006 resulting in possible operational upset	14.3.1.1. PDAH-101			
	15. No/less Flow (TW1002 overhead line)	15.1. Unexpected closure of HV-133	15.1.1. Pressure build-up overtime dowstream valve PCV-B41540 up to 65 barg and potential overpressurization...	15.1.1.1. Discrepancy alarm provide for HVs 15.1.1.2. PAH/PAHH-...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Flow

Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	15. No/less Flow (TW1002 overhead line) (cont.)	15.1. Unexpected closure of HV-133 (cont.)	...(DP=52 barg) with mechanical damage, loss of containment and potential for fire/explosion	...B40622 and operator response 15.1.1.3. SSV-B41520/B41530 (mechanical/pneumatical devices to cut off natural gas supply)			
			15.1.2. Loss of natural gas to downstream sections (see relevant nodes)				
	16. No/less Flow (TW1002 bottom side)	16.1. Unexpected closure of LV-146 or malfunction of LIC-152 closing LV-152	16.1.1. Level build up in TW1002 bottom section, according to limited inventory of amine complete overfilling is not expected.				
			16.1.2. Loss of reach amine supply to flash vessel/stripping column resulting in loss of lean amine supply to TW1002 overtime and consequent CO2 carry over to downstream section with potential impact on cold box (see relevant nodes)	16.1.2.1. LAHH-126 to activate closure of HV-105, HV-106 (same actions are also initiated by LAHH-127 on S1001) 16.1.2.2. PDI-125 to give alarm for high DP and to activate closure of HV-105, HV-106 in case of high high DP 16.1.2.3. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			

Worksheet

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Flow
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	17. No/less Flow (nitrogen supply to cold flare header)	17.1. Inadvertent closure of manual valve	17.1.1. Negligible impact since multiple sources of flushing nitrogen to cold flare are in place				
More	18. More Flow (NG feed to TW1002)	18.1. Higher demand rate of natural gas (JT valve PV-703 malfunction)	18.1.1. Higher flowrate of gas TW-1002 and potential for indequate CO2 removal and consequent CO2 carry over to downstream section with potential impact on cold box (see relevant nodes)	18.1.1.1. FIC-713 to limit natural gas flowrate 18.1.1.2. PDAH-125 and operator response 18.1.1.3. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
Reverse	19. Reverse Flow	19.1. No causes identified on natural gas side 19.2. No caused identified for natural gas backflow into nitrogen circuit since double block and bleed valve (FC) are provided (initiated by shut-down and depressurizing sequence)					
Misdirect	20. Misdirect Flow	20.1. HV-602 or HV-106 left opened after start-up	20.1.1. No impact				
		20.2. Inadvertent opening of mercury trap F1005 by-pass line	20.2.1. Possible mercury carry-over to downstream section resulting in potential damage of equipment overtime (long term scenario) and reduction of relevant lifetime	20.2.1.1. Routine inspection and procedure			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Flow
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	20. Misdirect Flow (cont.)	20.3. Unexpected opening of HV-164	20.3.1. Significant portion of natural gas sent to cold flare resulting in possible environmental concern	20.3.1.1. Discrepancy alarm on HVs 20.3.1.2. PDI-105 to give alarm for high DP and to activate closure of HV-105, HV-106 in case of high high DP 20.3.1.3. Restriction orifice RO-169 to limit flowrate			

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Temperature
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	21. Lower Temperature	21.1. Loss of heating medium to HW6000 including TIC-600 malfunction closing relevant TV	21.1.1. Lower temperature of natural gas routed to TW1002 (10 °C instead of 30°C) resulting in inadequate CO2 removal and consequent carry over to downstream sections (see relevant nodes)	21.1.1.1. TAL/TALL-119 activate closure of HV-600, HV-602 21.1.1.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		21.2. Refer to Low temperature in Node #01A	21.2.1. Lower temperature of natural gas routed to TW1002 (10 °C instead of 30°C) resulting in inadequate CO2 removal and consequent carry over to...	21.2.1.1. TAL/TALL-119 activate closure of HV-600, HV-602 21.2.1.2. AI-1012 to...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Temperature
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	21. Lower Temperature (cont.)	21.2. Refer to Low temperature in Node #01A (cont.)	...downstream sections (see relevant nodes)	...provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		21.3. Low ambient temperature	21.3.1. Possible freezing of stagnant piping on rich amine side	21.3.1.1. Electrical tracing and insulation provided on rich amine piping (electrical tracing also supplied by EDG)	8. Investigate appropriate monitoring system to check functionality/effectiveness of electrical tracing systems	SIAD MI	
More	22. Higher Temperature	22.1. Refer to Higher temperature in Node #01A					
		22.2. Malfunction of TIC-600 providing higher duty to exchanger HW6000 by opening relevant TV	22.2.1. Higher temperature of natural gas routed to TW1002 resulting in inadequate CO2 removal and consequent carry over to downstream sections (see relevant nodes)	22.2.1.1. TAH/TAHH-119 activate closure of HV-600, HV-602 22.2.1.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Pressure

Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	23. Lower Pressure	23.1. Loss of feed from BL (Refer to No/Less flow in Node #01A)	23.1.1. Inadequate CO2 removal and consequent carry over to downstream sections (see relevant nodes)	23.1.1.1. PAL/PALL-604 activate closure of HV-600, HV-602 23.1.1.2. PAL/PALL-122 activate closure of HV-105, HV-106 23.1.1.3. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		23.2. Inadequate pressurization at start-up (HV-106 does not open on demand)	23.2.1. Possible impact to F1005 internals due to high DP when HV-105 is open with loss of efficiency and possible reduced lifetime	23.2.1.1. Permissive to not open HV-105 below minimum set point initiated by PT-122			
More	24. Higher Pressure	24.1. Refer to No/Less flow in this node					
		24.2. Refer to More Pressure in node #01A					
		24.3. External fire	:		:See 7		
		24.4. Trapped gas between HV-600 and HV-105	24.4.1. Possible thermal expansion of trapped gas with no impact since estimated pressure build-up is lower than 52 barg (DP)				
		24.5. PCV-602 malfunction (fully open)	24.5.1. Higher pressure of natural gas routed to analyser (44 barg...		:See 6		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Pressure
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	24. Higher Pressure (cont.)	24.5. PCV-602 malfunction (fully open) (cont.)	...instead of 1 barg) with potential overpressurization of analysers (AI-1001, 1010, 1011, 1016) and associated items (DP= 0.5 barg) with mechanical damage and potential injuries to personnel		:See 6 (cont.)		

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Level
Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	25. No/less Level	25.1. Malfunction of LIC-152 fully opening LV-152 on TW-1002 bottom side	25.1.1. Loss of level on TW-1002 and consequent gas breakthrough (44 barg) to flash vessel S1003 (DP=10 barg) leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage	25.1.1.1. LALL-144 activate closure of LV-146 (same function is also initiated by PAHH-172) 25.1.1.2. PSV-167 on S1003 sized including gas breakthrough scenario			Capacity of S1003 is adequate to handle incoming liquid from TW1002 in case of wide opening of LV-152 in order to exclude potential overfilling scenario
More	26. Higher Level	26.1. Refer to No/Less flow in this node 26.2. No causes identified for S1001					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Composition

Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	27. Different Composition	27.1. See previous deviation 27.2. See node #06 for off-spec lean amine					

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Intention: HW6000 shell side: OTin = 10 °C, OTout = 30 °C
TW1002: OT ~ 54°C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Services / Utilities

Equipment: HW6000, F1005, F1006, TW1002, S1001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	28. No Services / Utilities	28.1. Loss of utilities	28.1.1. No additional scenario identified (see previous deviation)				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Flow
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	29. No/less Flow	29.1. Loss of natural gas supply from BL (any cause relevant to node #01A, #01B)	29.1.1. No impact on this node 29.1.2. Loss of natural gas feed to steam generator burners leading to loss of LP steam production leading to plant shut-down 29.1.3. Loss of natural gas feed to steam generator burners (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer) 29.1.4. Loss of natural gas feed to thermal-oxidizer pilots and main burners resulting in operational upset including possible plant shut-down 29.1.5. Loss of natural gas feed to thermal-oxidizer pilots and main burners (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer)				
		29.2. Unexpected isolation within feed gas module MDL6000	29.2.1. Loss of natural gas feed to steam generator burners leading to loss of LP steam production leading to plant shut-down 29.2.2. Loss of natural gas feed to steam generator burners (see dedicated HAZARD analysis/any other technical documentation...				

Worksheet

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Flow
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	29. No/less Flow (cont.)	29.2. Unexpected isolation within feed gas module MDL6000 (cont.)	...provided by manufacturer) 29.2.3. Loss of natural gas feed to thermal-oxidizer pilots and main burners resulting in operational upset including possible plant shut-down 29.2.4. Loss of natural gas feed to thermal-oxidizer pilots and main burners (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer) 29.2.5. Negligible impact on usptream sections				
		29.3. Unexpected closure of PCV-1581	29.3.1. Loss of natural gas feed to steam generator burners leading to loss of LP steam production leading to plant shut-down 29.3.2. Loss of natural gas feed to steam generator burners (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer)				
		29.4. Unexpected closure of PCV-1650	29.4.1. Loss of natural gas feed to thermal-oxidizer pilots and main burners resulting in operational upset including possible plant shut-down 29.4.2. Loss of natural gas feed...				

Worksheet

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Flow
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	29. No/less Flow (cont.)	29.4. Unexpected closure of PCV-1650 (cont.)	...to thermal-oxidizer pilots and main burners (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer)				
More	30. More Flow	30.1. No significant cause identified					
Reverse	31. Reverse Flow	31.1. No causes identified					
Misdirect	32. Misdirect Flow	32.1. No causes identified					

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Temperature
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	33. Lower Temperature	33.1. Lower temperature of natural gas from upstream section (see node #01B)	33.1.1. Natural gas routed to feed gas module at 10 °C instead of 30 °C and consequent lower temperature to users (estimated -17 °C) leading to possible operational upset. No impact on mechanical integrity on piping (MDMT = -29°C)	33.1.1.1. TAL-601 / TALL-601 to close HV-600			
			33.1.2. Lower temperature of natural gas sent to users (see relevant HAZARD analysis/technical documentation)	33.1.2.1. TAL-601 / TALL-601 to close HV-600			
More	34. Higher Temperature	34.1. Higher temperature of natural gas from upstream...	34.1.1. No significant impact				

Worksheet

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Temperature
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	34. Higher Temperature (cont.)	...section (see node #01B)	34.1.1. No significant impact (cont.)				

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Pressure
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	35. Lower Pressure	35.1. See no/less flow					
More	36. Higher Pressure	36.1. Malfunction of pressure controller on feed gas module	36.1.1. Higher pressure of natural gas at feed gas module outlet resulting in potential overpressurization, mechanical damage, natural gas leak and fire / explosion hazard	36.1.1.1. Shut-off valves provided within MDL6000 as per national regulation 36.1.1.2. PAHH-601 to activate closure of HV-600 36.1.1.3. PSV-605 sized including this scenario			
		36.2. Malfunction of PCV-1581 (fully open)	36.2.1. Higher pressure of natural gas routed to steam boiler burners (44 barg instead of 2 barg) (see dedicated HAZARD analysis/any other technical documentation provided by manufacturer)				
		36.3. Malfunction of PCV-1615 (fully open)	36.3.1. Higher pressure of natural gas routed to thermal oxidizer burners and main pilots (44 barg instead of 2 barg) (see dedicated HAZARD analysis/any other technical documentation...				

Worksheet

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Pressure
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	36. Higher Pressure (cont.)	36.3. Malfunction of PCV-1615 (fully open) (cont.)	...provided by manufacturer)				

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Level
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	37. No/less Level	37.1. Not applicable					
More	38. Higher Level	38.1. Not applicable					

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Composition
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	39. Different Composition	39.1. No causes identified					

Session: (1) 27/03/2023
Node: (02) Natural gas supply to steam generator
Intention: RS6000: m= 70 kg/h; OPin = 43,9 barg, OPout = 2 barg; OTin = 30 °C, OTout = 6 °C
Notes:
Drawings: I20784 Sh 10; I20784 Sh 11; I20784 Sh 50; I20784 Sh 70
Parameter: Services / Utilities
Equipment: RS6000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	40. No Services / Utilities	40.1. Not applicable					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Flow Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	41. No/less Flow (Overhead line)	41.1. Malfunction of PIC-171 closing PV-171 or PV spurious closure	41.1.1. Pressure build up in S1003 leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage	41.1.1.1. PAHH-172 to activate closure of LV-146 41.1.1.2. PSV-167 sized including this scenario			
			41.1.2. Loss of amine flash gas to NG regeneration cooler with negligible impact (9 Nm3/h vs overall stream 260 Nm3/h)				
	42. No/less Flow (Hydrocarbon line)	42.1. Malfunction of LIC-158 closing LV-158 or not opening on demand or spurious closure of LV-143	42.1.1. Hydrocarbon accumulation overtime on S1003 leading to potential HC carry over to TW2008 and TW1002 resulting in foaming and consequent operational upset	42.1.1.1. Periodical sampling and operator response (antifoam injection available)			
	43. No/less Flow (Rich amine)	43.1. Malfunction of LIC-163 closing LV-163 or not opening on demand or spurious closure of LV-151	43.1.1. Increase of level in S1003, overfilling is not expected taking into account void space available in S1003 compared to hold up in TW2008 and TW1002				
			43.1.2. Increase of level in S1003 leading to rich amine overflow inside HC bucket and consequent possible amine carry-over to thermal oxidizer KO drum with operational upset and no safety concern	43.1.2.1. LAHH-154 to activate closure LV-146			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Flow
Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	43. No/less Flow (Rich amine) (cont.)	43.1. Malfunction of LIC-163 closing LV-163 or not opening on demand or spurious closure of LV-151 (cont.)	43.1.3. Loss of reach amine supply to stripping column resulting in loss of lean amine supply to TW1002 overtime and consequent CO2 carry over to downstream section with potential impact on cold box (see relevant nodes)	43.1.3.1. LAL-202 and operator response 43.1.3.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
			43.1.4. Loss of reach amine supply to stripping column resulting in loss of level and potential damage to P-2005A/B due to dry-running with potential localized NG leakage due to backflow from TW1002 resulting in possible fire and injuries to personnel	43.1.4.1. LAL-202 and operator response 43.1.4.2. LALL-209 activate trip of pump P-2005A/B and to close HV-138			
More	44. More Flow	44.1. No causes identified					
Reverse	45. Reverse Flow (NG side)	45.1. No causes identified for backflow from gas regeneration cooler according to operating condition downstream cooler itself (OP approximately 1.5 barg)					
	46. Reverse Flow (HC side)	46.1. No causes identified for backflow from oxidizer suction KO drum through HC discharge line (OP approximately 0.1 barg)					
	47. Reverse Flow (rich amine)	47.1. No causes identified for backflow from TW2008...					

Worksheet

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Flow
Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Reverse (cont.)	47. Reverse Flow (rich amine) (cont.)	...according to operating condition (OP approximately 0.9 barg)					
Misdirect	48. Misdirect Flow	48.1. No causes identified					

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Temperature
Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	49. Lower Temperature	49.1. No significant process causes identified					
		49.2. Low ambient temperature	49.2.1. Possible freezing of stagnant piping on rich amine side	49.2.1.1. Electrical tracing and insulation provided on rich amine piping (electrical tracing also supplied by EDG)	:See 8		
More	50. Higher Temperature	50.1. No causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Pressure
Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	51. Lower Pressure	51.1. Malfunction of PIC-171 fully opening PV-171	51.1.1. Pressure decrease in S1003 resulting in inadequate driving force to push rich amine to stripping unit (Refer to No/Less Flow consequences) 51.1.2. No impact on downstream system				
More	52. Higher Pressure	52.1. Gas breakthrough scenario from TW1002 (see node #01B)					
		52.2. Blocked outlet (see no/less flow in this node)					
		52.3. Gas breakthrough scenario from HW4001 (see Node #04)					
		52.4. External fire	52.4.1. Overpressurization of involved equipment/piping with possible mechanical damage	52.4.1.1. PSV-167 sized including external fire			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Level

Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	53. No/less Level (Hydrocarbon side)	53.1. Malfunction of LIC-158 fully opening LV-158	53.1.1. Loss of HC level on HC bucket and consequent gas breakthrough (5 barg) to thermal oxidizer KO drum V16200 (DP > 5 barg). No impact on mechanical integrity				V16200 DP to be finalized (at least same of DP of flash vessel S1003, 10 barg)
			53.1.2. Minor economical losses due to routing of NG to thermal oxidizer	53.1.2.1. LSLL-104 activate closure of LV-143			
	54. No/less Level (rich amine)	54.1. Malfunction of LIC-163 fully opening LV-163	54.1.1. Loss of amine level on S1003 and consequent gas breakthrough (5 barg) to stripping column TW2008 (DP= 2 barg) with potential mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage	54.1.1.1. LALL-164 activate closure of LV-151 54.1.1.2. PSV-271 sized including gas breakthrough scenario			
More	55. Higher Level	55.1. Refer to No/Less flow in this node					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (03) Flash vessel
Intention: S1003: OT ~ 54°C
HW2007: OTin = 54°C; OTout = 99°C
OP = 5 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 15; I20784 Sh 36
Parameter: Composition
Equipment: S1003, HW2007

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	56. Different Composition	56.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Flow
Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	57. No/less Flow (gas)	57.1. No/Less Flow from upstream section	57.1.1. No impact on this node				
	58. No/less Flow (condensate)	58.1. Malfunction of LIC-419 closing LV-419 or not opening on demand or spurious closure of LV-413	58.1.1. No impact on flash vessel S1003				
			58.1.2. Level build up on precooler condensate separator ST4001 resulting in possible overfilling and liquid carry over to dryers with potential for damage of adsorbent material, economical losses and no safety concern	58.1.2.1. LAHH-411 activate closure HV105, HV106 58.1.2.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
More	59. More Flow	59.1. No causes identified					
Reverse	60. Reverse Flow	60.1. No causes identified					
Misdirect	61. Misdirect Flow	61.1. Tube rupture in HW4001	61.1.1. NG (44 barg) enters into HW4001 shell side (DP= 8 barg) and potential overpressuriization on chilled water circuit resulting in mechanical damage and loss of containment of natural gas, potential fire/explosion and injuries to personnel due to mechanical damage	61.1.1.1. PSV-478 sized for this scenario (routed to cold flare)			
		61.2. HV-130 left opened after start-up	61.2.1. No impact				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Temperature

Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	62. Lower Temperature	62.1. Malfunction of TIC-486 fully opening TV-486 on chilled water circuit	62.1.1. Lower temperature on natural gas resulting in potential hydrates formation and possible plugging overtime leading to operational upset	62.1.1.1. TALL-421 activate closure of HV-105 and HV-106			
		62.2. Low ambient temperature	62.2.1. Possible freezing of stagnant piping on condensate side	62.2.1.1. Electrical tracing and insulation provided on condensate piping (electrical tracing also supplied by EDG)	:See 8 9. Provide winterization on low points where condensation may happen on naturale gas line from TW1002 to HW4001	 SIAD MI	
More	63. Higher Temperature	63.1. Loss of chilled water including malfunction of TIC-486 closing TV-486	63.1.1. Loss of water condensation on natural gas stream leading to reduced efficiency of dryer section and potential for umidy slippage to cold box (see relevant node)	63.1.1.1. TAHH-421 activate closure of HV-105 and HV-106 63.1.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Pressure
Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	64. Lower Pressure	64.1. Inadequate pressurization at start-up (HV-130 does not open on demand)	64.1.1. Possible impact to downstream equipment (online dryers) due to high DP when HV-133 is open with possible damage to internals and economical losses	64.1.1.1. Permissive to not open HV-133 below minimum set point initiated by PT-122/439/440/441			
More	65. Higher Pressure	65.1. Refer to misdirect flow (tube tupture in HW4001)					
		65.2. External fire	:		:See 7		
		65.3. Trapped liquid on HW4001 shell side	65.3.1. Thermal expansion of trapped chilled water resulting in mechanical damage and economical losses	65.3.1.1. PSV-478 sized for this scenario			

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Level
Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	66. Lower Level	66.1. Malfunction of LIC-419 fully opening LV-419	66.1.1. Loss of level on ST-4001 and consequent gas breakthrough (44 barg) to flash vessel S1003 (DP=10 barg) leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to...	66.1.1.1. LALL-472 activate closure of LV-413 66.1.1.2. PSV-167 on S1003 sized including gas breakthrough scenario	10. Closure of LV-413 shall be also initiated by PAHH-172	SIAD MI	

Worksheet

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Level
Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	66. Lower Level (cont.)	66.1. Malfunction of LIC-419 fully opening LV-419 (cont.)	...mechanical damage	66.1.1.2. PSV-167 on S1003 sized including gas breakthrough scenario (cont.)	10. Closure of LV-413 shall be also initiated by PAHH-172 (cont.)		
More	67. Higher Level	67.1. Refer to No/Less flow					

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Intention: HW4001: OTin = 50 °C, OTout = 20 °C, OPchilled water = 3 barg
OP = 44 barg
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Composition
Equipment: HW4001, ST4001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	68. Different Composition	68.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Flow
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	69. No/less Flow	69.1. Pump P3001 failure when required in operation	69.1.1. Interruption of pure amine make-up and consequent delay in operation (according to operating manual, additional sampling is required after make-up)	69.1.1.1. Totalizer FIQ-304 69.1.1.2. Dicrepancy alarm/electrical fault signal for pump status reported to PLC			
More	70. More Flow	70.1. Improper make-up operation (excessive amount)	70.1.1. Higher amount of pure amine with no significant consequences on process side. Minor economical losses				
Reverse	71. Reverse Flow	71.1. Pump P3001 failure when required in operation	71.1.1. Possible backflow from lean amine circuit with potential contamination of fresh amine and economical losses/potential overfilling of IBC and potential for soil contamination	71.1.1.1. Dicrepancy alarm/electrical fault signal for pump status reported to PLC 71.1.1.2. Presence of two check valves in series 71.1.1.3. IBC located inside curbed area with adequate impermeable material			
Misdirect	72. Misdirect Flow	72.1. Wrong line up of connection between P3001 discharge and V3004	72.1.1. Make-up amine batch routed to V3004 instead of to lean amine circuit resulting in minor economical losses/operational upset due to delay in operation. No impact on V3004 according to limited amount involved				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Temperature
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	73. Lower Temperature	73.1. Low ambient temperature	73.1.1. No impact on pure amine circuit according to its freezing point (-48°C)				
			73.1.2. Potential freezing on portions of piping where lean amine can be possibly present and consequent mechanical damage	73.1.2.1. Winterization provided between first check valve on pump P3001 discharge and injection point	:See 8		
More	74. Higher Temperature	74.1. No causes identified					

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Pressure
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	75. Lower Pressure	75.1. Refer to No/Less flow (pump failure)					
More	76. Higher Pressure	76.1. Inadvertent closure of valve on pump discharge line	76.1.1. Pressure build up in blocked outlet piping up to P3001 shut off pressure (estimated < 5 barg). No impact on piping mechanical integrity (ANSI150)				

Worksheet

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Level
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	77. No/less Level	77.1. Unappropriate monitoring of level in IBC	77.1.1. Emptying of IBC during fresh amine transfer and potential damage to P3001 due to dry running, economical losses		11. Provide additional gauging system to monitor level inside amine IBC (e.g. pressure gauge on bottom outlet line to P3001 pump suction, etc.)	SIAD MI	
More	78. Higher Level	78.1. No causes identified					

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Composition
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	79. Different Composition	79.1. No additional causes identified					

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Intention: System used for periodical pure amine make up after weekly sampling (if make up is required)
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Services / Utilities
Equipment: Amine IBC, P3001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	80. No Services / Utilities	80.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	81. No/less Flow (lean amine to TW1002)	81.1. Failure of pump P2005A/B	81.1.1. Level build up in TW2008, overfilling is not expected since capacity of this equipment can accomodate overall amine inventory				
			81.1.2. Level build up in TW2008 resulting in temperature build up on bottom section (<150°C) with negligible impact on amine (degradation temperature around 180°C)				
			81.1.3. Loss of lean amine supply to TW1002 and consequent inadequate CO_2 removal and consequent CO_2 slippage to cold box (see relevant node)	81.1.3.1. Discrepancy signal from onduty P2005A/B starting stand-by pump 81.1.3.2. FAL-230 and operator response 81.1.3.3. AI-1012 to provide a high CO_2 concentration alarm and to close HV-700 on high high CO_2 concentration through ESD			
		81.2. Malfunction of FIC-227 to reduce rpm of pump P2005A/B through relevant VFD	81.2.1. Reduced of lean amine supply to TW1002 and consequent inadequate CO_2 removal and consequent CO_2 slippage to cold box (see relevant node)	81.2.1.1. AI-1012 to provide a high CO_2 concentration alarm and to close HV-700 on high high CO_2 concentration through ESD	12. Add a low pressure alarm to PI-201A/B	SIAD MI	

Worksheet

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	81. No/less Flow (lean amine to TW1002) (cont.)	81.3. Unexpected closure of HV-138 on TW1002 inlet line	81.3.1. Level build up in TW2008, overfilling is not expected since capacity of this equipment can accomodate overall amine inventory				
			81.3.2. Level build up in TW2008 resulting in temperature build up on bottom section (<150°C) with negligible impact on amine (degradation temperature around 180°C)				
			81.3.3. Loss of lean amine supply to TW1002 and consequent inadequate CO2 removal and consequent CO2 slippage to cold box (see relevant node)	81.3.3.1. Discrepancy alarm on HVs 81.3.3.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
			81.3.4. Pressure build up on blocked in piping up to P-2005A/B shut-off pressure (approximately 52 barg). No impact on mechanical integrity of piping and equipment according to design criteria				
			81.3.5. Potential damage to P-2005A/B overtime due to prolonged operation in blocked...	81.3.5.1. PAH-201A/B 81.3.5.2. Unit is located...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	81. No/less Flow (lean amine to TW1002) (cont.)	81.3. Unexpected closure of HV-138 on TW1002 inlet line (cont.)	...outlet condition resulting in economical losses/possible amine spillage and soil contamination	...inside curbed area with adequate impermeable material			
	82. No/less Flow (lean amine recirculation)	82.1. PCV-229 malfunction (close position)	82.1.1. Loss of lean amine filtration resulting in possible increasing foaming tendency in TW2008 and process upset	82.1.1.1. FAL-230 and operator response 82.1.1.2. Periodical sampling and availability of antifoaming agent			
		82.2. Plugging of cartridge filter F2002/F2003	82.2.1. Increased DP accross cartridge filter F2002/F2003 leading to cartridge damage overtime (minor economical losses)	82.2.1.1. PDAH-243			It's not credible plugging of carbon filter F2001
	83. No/less Flow (Overhead circuit)	83.1. Malfunction of PIC-275 closing PV-275 on CO2 vent to thermal oxidizer	83.1.1. Pressure build up on TW2008 and S2011 (DP=2barg) leading to potential overpressurization overtime, mechanical damage and injuries to personnel	83.1.1.1. PAHH-282 activate closure of FV-204 83.1.1.2. PSV-271 sized including this scenario	13. Add closure of LV-151 among actions initiated by PAHH-282 14. Investigate appropriate routing of PSV-271 (currently routed to atm at safe location) taking into account either potential presence of amine and requirements from national regulation	SIAD MI SIAD MI / OGE	
			83.1.2. No impact on thermal oxidizer due to loss of CO2 vent...				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	83. No/less Flow (Overhead circuit) (cont.)	83.1. Malfunction of PIC-275 closing PV-275 on CO2 vent to thermal oxidizer (cont.)	...stream				
	84. No/less Flow (Bottom circuit)	84.1. Failure of pump P2012A/B	84.1.1. Level build up in S2011 leading to possible overfilling resulting in HW2010 flooding, loss of condensation and pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, damage and injuries to personnel	84.1.1.1. Discrepancy signal from onduty P2012A/B starting stand-by pump 84.1.1.2. LAHH-279 activate closure of FV-204 (same action is initiated by PAHH-282) 84.1.1.3. PSV-271 sized including this scenario	15. Add closure of LV-151 among actions initiated by LAHH-279	SIAD MI	
			84.1.2. Level build up in S2011 leading liquid carry over to thermal oxidizer KO drum with operational upset	84.1.2.1. Discrepancy signal from onduty P2012A/B starting stand-by pump 84.1.2.2. LAHH-279 activate closure of FV-204	:See 15		
		84.2. Malfunction of LIC-278 closing LV-278	84.2.1. Level decrease in S2011 leading to possible damage to P2012A/B due to dry running and consequent economical losses	84.2.1.1. LALL-280 activate trip of P2012A/B			
More	85. More Flow	85.1. Malfunction of FIC-227 to increase rpm of pump P2005A/B through relevant VFD	85.1.1. Increased recirculation flowrate for amine resulting in loss of efficiency in amine...	85.1.1.1. PAH-201A/B 85.1.1.2. AI-1012 to...			

Worksheet

Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	85. More Flow (cont.)	85.1. Malfunction of FIC-227 to increase rpm of pump P2005A/B through relevant VFD (cont.)	...regeneration ultimately resulting in CO_2 slippage to cold box (see relevant node)	...provide a high CO_2 concentration alarm and to close HV-700 on high high CO_2 concentration through ESD			
Reverse	86. Reverse Flow	86.1. Failure of pump P2005A/B	86.1.1. Possible natural gas reverse flow from TW1002 (44barg) to TW2008 (DP=2barg) leading to pressure build up in stripping column, mechanical damage and potential for injuries to personnel including fire/explosion hazard	86.1.1.1. Discrepancy signal from onduty P2005A/B starting stand-by pump	16. Add dedicated interlock to shut down HV-138 in case of back flow due to both P2005A/B not running (e.g. high high pressure detected on common pump suction line)	SIAD MI	
					17. Add additional check valve dissimilar type at lean amine injection line in TW1002	SIAD MI	
		86.2. No causes identified for backflow on CO_2 vent line to thermal oxidizer					
Misdirect	87. Misdirect Flow	87.1. Tube rupture in HW2009	87.1.1. LP steam enters the column TW2008 with pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, mechanical damage and injuries to personnel	87.1.1.1. PAHH-282 activate closure of FV-204 87.1.1.2. PSV-271 sized including this scenario			
		87.2. Malfunction of LIC-202...	87.2.1. Level build up in S2011...	87.2.1.1. LAHH-279...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	87. Misdirect Flow (cont.)	...leading to unexpected opening of LV-291 on demi water supply to S2011	...leading to possible overfilling resulting in HW2010 flooding, loss of condensation and pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, damage and injuries to personnel 87.2.2. Level build up in S2011 leading liquid carry over to thermal oxidizer KO drum with operational upset	...activate closure of LV-291 (same action is initiated by PAHH-282) 87.2.1.2. PSV-271 sized including this scenario 87.2.2.1. LAHH-279 activate closure of LV-291			

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Temperature
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	88. Lower Temperature	88.1. Malfunction of TIC-226 fully opening TV-226	88.1.1. Lower temperature of lean amine (minimum estimated 40°C instead of 50°C) to absorber TW-1002 resulting in slight loss of efficiency and CO2 minor slippage to cold box (less critical than other case)	88.1.1.1. Event detectable by TI-222 88.1.1.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2...			

Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Temperature
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	88. Lower Temperature (cont.)	88.1. Malfunction of TIC-226 fully opening TV-226 (cont.)	88.1.1. Lower temperature of lean amine (minimum estimated 40°C instead of 50°C) to absorber TW-1002 resulting in slight loss of efficiency and CO2 minor slippage to cold box (less critical than other case) (cont.)	...concentration through ESD			
		88.2. Malfunction of TIC-204 (or TIC-263)/FIC-204 closing FV-204 or any other cause for loss of LP steam to reboiler HW2009	88.2.1. Inadequate stripping resulting in off spec lean amine to absorber TW-1002 resulting in loss of efficiency and CO2 slippage to cold box (See relevant node)	88.2.1.1. TAL-214 and operator response 88.2.1.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		88.3. Malfunction of TIC-272 fully opening TV-272	88.3.1. Level build up in S2011 resulting in operational upset leading to slight reduction of amine with negligible impact				
		88.4. Malfunction of TI-203 to switch off H2001 or loss of electrical power to H2001	88.4.1. Possible water condensation on CO2 vent stream to thermal oxidizer KO drum leading to minor operational upset	88.4.1.1. Discrepancy status of electrical heater reported to PLC			
		88.5. Low ambient temperature	88.5.1. Possible freezing of stagnant piping on condensate side	88.5.1.1. Electrical tracing and insulation provided on condensate piping (electrical tracing also supplied by EDG)	:See 8		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Temperature
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	89. Higher Temperature	89.1. Malfunction of TIC-226 closing TV-226	89.1.1. Lean amine at 80 °C instead of 50°C routed to absorber TW-1002 leading to loss of efficiency and CO2 slippage to cold box (See relevant node)	89.1.1.1. TAHH-222 activate closure of HV-105, HV-106 89.1.1.2. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		89.2. Malfunction of TIC-204 (or TIC-263)/FIC-204 fully opening FV-204	89.2.1. Increased vaporization in TW2008 leading to higher consumption of demi water with operational upset				
		89.3. Higher temperature of LP steam from BL	89.3.1. Higher temperature on HW2009 tubes resulting in potential increased amine degradation rate with operational upset overtime	89.3.1.1. TAHH-267 activate closure of FV-204			
		89.4. Malfunction of TIC-272 closing TV-272	89.4.1. Loss of cooling water to condender resulting in increased losses of water to thermal oxidizer KO drum leading to minor operational upset	89.4.1.1. Event detectable by FIQ-208			
		89.5. Malfunction of TI-203 to switch on H2001 when not required	89.5.1. No impact during normal operation (maximum reachable temperature on CO2 vent stream is approximately 15 °C)				
		89.6. Blocked outlet condition...	89.6.1. Possible overheating of...	89.6.1.1. TAHH-211...			

Worksheet

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Temperature
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	89. Higher Temperature (cont.)	...for CO2 vent gas stream (PV-275 closure)	...H2001 and piping (DT = 90°C) with potential mechanical damage and loss of containment of hot product with personnel injuries	...activate trip of heater H2001			
			89.6.2. Possible damage to thermal element of H2001 with consequent economical losses	89.6.2.1. TAHH-212 activate trip of first heater H2001 electrical bundle 89.6.2.2. TAHH-213 activate trip of second heater H2001 electrical bundle			

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Pressure
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	90. Lower Pressure	90.1. Refer to No/Less flow in this node					
		90.2. Malfunction of PIC-275 fully opening PV-275 on CO2 vent to thermal oxidizer	90.2.1. Pressure decrease in TW2008 from 0,9 barg to approximately atmospheric pressure leading to temperature...	90.2.1.1. TAL-214 and operator response 90.2.1.2. AI-1012 to...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Pressure
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	90. Lower Pressure (cont.)	90.2. Malfunction of PIC-275 fully opening PV-275 on CO2 vent to thermal oxidizer (cont.)	...decrease and consequent inadequate stripping resulting in off spec lean amine to absorber TW-1002 resulting in loss of efficiency and CO2 slippage to cold box (See relevant node) 90.2.2. Negligible impact on downstream equipment (thermal oxidizer)	...provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD			
		90.3. Unit shut down and consequent equipment isolation	90.3.1. Possible vacuum condition in HW2009 steam side (shell side) with no impact in mechanical integrity according to design criteria (FV requirement) 90.3.2. According to presence of inert gas, no vacuum conditions are expected for stripper and condensate separator however all stripping sections are designed for FV				
More	91. Higher Pressure	91.1. Refer to gas breakthrough scenario in node #03 91.2. Refer to No/Less flow in this node 91.3. Refer to Reverse flow in this node					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Pressure
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	91. Higher Pressure (cont.)	91.4. Malfunction of PCV-229 (fully open)	91.4.1. Lean amine at 44 barg sent to F2001, F2002 and F2003 (DP = 8 barg) resulting in possible overpressurization, mechanical damage and injuries to personnel	91.4.1.1. PAH/PAHH-289 activate trip of P-2005A/B 91.4.1.2. PSV-203 sized for this scenario			
		91.5. Unexpected start up of stand-by P-2005A/B	91.5.1. Transient pressure build up on P-2005A/B discharge below shut-off condition. Negligible impact				
		91.6. Unexpected start up of stand-by P-2012A/B	91.6.1. Pressure build up on P-2012A/B discharge below shut-off condition (approximately 4 barg). No impact on mechanical integrity of piping according to design condition of piping (ANSI150). Possible transient operational upset				
		91.7. External fire	:		:See 7		
		91.8. Trapped liquid on heat exchangers	91.8.1. Thermal expansion leading to mechanical damage and consequent economical losses and potential minor injuries	91.8.1.1. PSV-294 to protect HW2004 cold side 91.8.1.2. PSV-295 to protect HW2010 cold side 91.8.1.3. PSV-193 to protect HW2007 cold side			

Worksheet

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Level
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	92. No/less Level	92.1. Loss of rich amine feed from flash vessel (Refer to No/Less flow in node #03)					
		92.2. Malfunction of LIC-202/TIC-272 leading to reduced condensation rate in HW2010/inadequate demi water make-up through TV-291	92.2.1. Level decrease in TW2008 with loss of reach amine supply to stripping column resulting in loss of level and potential damage to P-2005A/B due to dry-running with potential localized NG leakage due to backflow from TW1002 resulting in possible fire and injuries to personnel	92.2.1.1. LALL-209 activate trip of pump P-2005A/B and to close HV-138	:See 16, 17		
		92.3. Malfunction of LIC-278 closing LV-278	92.3.1. Level decrease in S2011 and potential damage to P-2012A/B due to dry-running with consequent economical losses	92.3.1.1. LALL-280 activate trip of pump P-2012A/B			

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Composition
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	93. Different Composition	93.1. No additional causes identified					

Session: (3) 29/03/2023
Node: (06) MDEA stripping column
Intention: TW2008: OT ~ 111 °C
HW2007: OTin = 121,1 °C; OTout = 79,83°C; HW2004 OTout = 50°C
P2005A/B: OPsuction = 1,69 barg, OPdischarge = 47,25 barg
HW2010: OTin = 112 °C; OTout = 45 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Services / Utilities
Equipment: TW2008, HW2009, HW2010, S2011, P2012A/B, HW2007, P2005A/B, F2001, F2002, F2003

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	94. No Services / Utilities	94.1. Loss of power supply	94.1.1. Possible natural gas reverse flow from TW1002 (44barg) to TW2008 (DP=2barg) leading to pressure build up in stripping column, mechanical damage and potential for injuries to personnel including fire/explosion hazard		:See 16, 17		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Flow
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	95. No/less Flow	95.1. Failure of pump P3002 when required in operation	95.1.1. Delay in maintenance operation with minor upset	95.1.1.1. Possibility to replace P3002 with P3001			
More	96. More Flow	96.1. Operator mistake starting simultaneous drainage of different equipment	96.1.1. Possible level increase in V3004 leading to possible overfilling and amine release from vent line with possible injuries to personnel/soil contamination	96.1.1.1. Specific maintenance procedures which foresees single drainage at once 96.1.1.2. LAH/LAHH-305 activate trip of pump P3002 (used for equipment drainage) 96.1.1.3. MDEA blowdown tank located inside curbed area with adequate impermeable material	18. Provide overflow line for V3004 discharging to ground (located below inlet nozzle of PSV header)	SIAD MI	
Reverse	97. Reverse Flow	97.1. Failure of pump P3002 during trasfer to truck	97.1.1. Possible reverse flow from truck to MDEA blow down tank with negligible impact (delay in operation). Overfilling is not expected according to tank elevation.		19. Add check valve on P3002 discharge line to truck loading (downstream recirculation line)	SIAD MI	
Misdirect	98. Misdirect Flow	98.1. Operator error to open recirculation line during truck loading operation	98.1.1. Slight delay in operation with negligible impact				
		98.2. Inadvertent opening of valve X318 or valve passing	98.2.1. Possible contamination of fresh amine and consequent operational upset		20. Specify NC valve X307 on IBC bottom	SIAD MI	

Worksheet

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Temperature
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	99. Lower Temperature	99.1. Low ambient temperature	99.1.1. Potential for freezing of stagnant line leading to mechanical damage	99.1.1.1. Electrical tracing and insulation provided on amine piping and blowdown tank (electrical tracing also supplied by EDG) 99.1.1.2. Free draining requirement for MDEA PSV header	:See 8		
More	100. Higher Temperature	100.1. Operator mistake draining hot amine from TW2008 bottom (120 °C)	100.1.1. Possible overheating of V3004 (DT=60°C) resulting in mechanical damage and possible leakages (injuries to personnel/economical losses)	100.1.1.1. Specific drainage procedure which foresees adequate amine cooling before transfer to V3004 100.1.1.2. TAL-214 to give permission to pump P3002 to start only if temperature is adequate for transfer to blowdown tank	21. Relocate TAL to give permission to pump P3002 to start from TT-214 to TT-127 22. Review V3004 design temperature up to 100 °C	SIAD MI SIAD MI	

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Pressure
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	101. Lower Pressure	101.1. No causes identified fot V3004 since open vented to atmosphere by 2" vent					
More	102. Higher Pressure	102.1. No causes identified fot V3004 since open vented to atmosphere by 2" vent					
		102.2. Pump P3002 blocked outlet condition	102.2.1. Pressure buil up on blocked in piping (including...		23. Ensure that flexible hoses used for amine...	OGE (TBF)	

Worksheet

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Pressure
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	102. Higher Pressure (cont.)	102.2. Pump P3002 blocked outlet condition (cont.)	...flexible hoses) up to pump sut-off pressure (approximately 4 barg). No impact on mechanical integrity of piping according to design criteria. Possible overpressurization of flexible hose resulting in amine solution leak and possible injuries to personnel/soil contamination		...transfer to truck have adequate design pressure to cope with shut-off pressure of P3002		

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Level
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	103. No/less Level	103.1. Operator does not stop P3002 on low level in V3004 (including LT-305 failure)	103.1.1. Possible damage to P3002 due to dry running with minor economical losses and delay in operation	103.1.1.1. LALL-305 activate the trip of pump (not effective in case of LT-305 failure) 103.1.1.2. Event detectable by PI-306 (operator is in place during transfer)	24. Add a level gauge on V3004	SIAD MI	
		103.2. Operator does not stop P3002 on low level in equipment under drainage	103.2.1. Possible damage to P3002 due to dry running with minor economical losses and delay in operation	103.2.1.1. Event detectable by PI-306 (operator is in place during transfer)			
More	104. Higher Level	104.1. Refer to More flow in this node					
		104.2. Malfunction of LT-305 leading to inadequate transfer of collected amine	104.2.1. Possible level increase in V3004 leading to possible overfilling and amine release from vent line with possible injuries...	104.2.1.1. MDEA blowdown tank located inside curbed area with adequate impermeable material	:See 18, 24		

Worksheet

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Level
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	104. Higher Level (cont.)	104.2. Malfunction of LT-305 leading to inadequate transfer of collected amine (cont.)	...to personnel/soil contamination	104.2.1.1. MDEA blowdown tank located inside curbed area with adequate impermeable material (cont.)	:See 18, 24 (cont.)		

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Intention: OP = atm, OT = Ambient.
Notes: V3004 can collect the maximum capacity of one section (max inventory of amine in flash vessel). The vessel is used only for maintenance operation, during plant stop.
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Composition
Equipment: V3004, P3002

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	105. Different Composition	105.1. No causes identified					

Worksheet

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package
Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Flow
Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	106. No/less Flow	106.1. Failure of P2013 when required in operation	106.1.1. Loss/Inadequate antifoam agent injection on demand and consequent increased foaming tendency on liquid stream resulting in operational upset	106.1.1.1. Periodical sampling 106.1.1.2. Discrepancy alarm provided for pump P2013			
More	107. More Flow	107.1. Increased flowrate through P2013 due to malfunction/excessive amount injected due to operator mistake	107.1.1. Minor economical losses due to consumption/possible plugging of carbon filter guard F2001 overtime due to antifoam agent accumulation	107.1.1.1. Periodical sampling 107.1.1.2. PDAH-243			
Reverse	108. Reverse Flow	108.1. Failure of P2013 when required in operation	108.1.1. Backflow from P2005A/B suction to antifoam agent drum is not expected since diaphragm pump is selected and check valve is available				
Misdirect	109. Misdirect Flow	109.1. Operator error lining up wrong injection point	109.1.1. Negligible impact				

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package
Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Temperature
Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	110. Lower Temperature	110.1. Unavailability of antifoam belt drum heater	110.1.1. Increased viscosity of antifoam agent and consequent possible inadequate injection of antifoam agent (see no/less flow but less critical)	110.1.1.1. Routine inspection			
		110.2. Low ambient temperature	110.2.1. Increased viscosity of antifoam agent and consequent possible inadequate injection of...	110.2.1.1. Electrical tracing and insulation provided on antifoam agent piping...	:See 8		

Worksheet

Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Temperature Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	110. Lower Temperature (cont.)	110.2. Low ambient temperature (cont.)	...antifoam agent (see no/less flow but less critical)	...(electrical tracing also supplied by EDG)	:See 8 (cont.)		
More	111. Higher Temperature	111.1. No causes identified					

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Pressure Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	112. Lower Pressure	112.1. Refer to No/Less flow in this node					
More	113. Higher Pressure	113.1. Blocked outlet for P2013	113.1.1. Possible damage to pump (economical losses)/potential overpressurization of downstream piping resulting in mechanical damage and potential injuries to personnel	113.1.1.1. Specific provedure for line up of antifoam agent injection line	25. Add pressure relief device on P2013 discharge line, sized for blocked outlet scenario	SIAD MI	

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Level Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	114. No/less Level	114.1. No cause identified					
More	115. Higher Level	115.1. No cause identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package
Intention:
Notes:
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Composition
Equipment: AF drum, P2013

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	116. Different Composition	116.1. No cause identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	117. No/less Flow	117.1. Loss of natural gas from upstream section (any cause)	117.1.1. No impact on this node				
		117.2. No causes identified for unexpected closure of HV-427 or HV-443 (FL valves managed by automatic sequence)					
		117.3. No causes identified for plugging of dryer bed					
		117.4. Plugging of F4005 overtime	117.4.1. Increased DP accross F4005 leading to operational upset on downstream section	117.4.1.1. PDAH-473			
		117.5. Unexpected closure of HV-700	117.5.1. No impact on this node and upstream system (pressure build up is not expected, however all natural gas loop from metering station let down valve to JT valve PV-703 is designed at same value (52 barg))	117.5.1.1. Discrepancy alarm on HVs 117.5.1.2. PAL-703			
			117.5.2. Loss of natural gas feed to cold box and associated equipment on cryogenic equipment (see node #11)	117.5.2.1. Discrepancy alarm on HVs 117.5.2.2. PAL-703			
More	118. More Flow	118.1. Higher demand rate of natural gas (JT valve PV-703 malfunction)	118.1.1. Higher flowrate of gas through dryers and potential for indequate humidity removal and consequent humidity carry over to downstream section with potential impact on cold box (see relevant nodes)	118.1.1.1. FIC-713 to limit natural gas flowrate 118.1.1.2. FAH-600 118.1.1.3. AI-1013A to provide a high H2O...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	118. More Flow (cont.)	118.1. Higher demand rate of natural gas (JT valve PV-703 malfunction) (cont.)	118.1.1. Higher flowrate of gas through dryers and potential for indequate humidity removal and consequent humidity carry over to downstream section with potential impact on cold box (see relevant nodes) (cont.)	...concentration alarm and to close HV-700 on high high H2O concentration through ESD			
Reverse	119. Reverse Flow	119.1. No causes identified					
Misdirect	120. Misdirect Flow	120.1. Wrong position for any KV in the position between high pressure stream and low pressure stream	120.1.1. Natural gas in operating mode (44 barg, 20 °C) routed to equipment and piping under regeneration mode. No impact on mechanical integrity according to design criteria (all the loop is designed at same condition)				
			120.1.2. Natural gas in operating mode (44 barg, 20 °C) routed to NG regeneration module (16 barg) resulting in possible overpressurization, mechanical damage and natural gas leak (possible fire/explosion)	120.1.2.1. Valve is FC 120.1.2.2. KV is managed by automatic sequence including discrepancy alarm to freeze the sequence (manual/semi-automatic mode of operation to manage software is not allowed) 120.1.2.3. PAHH-528 activate closure of PV-527 (for depressurization circuit) or PAHH-531 activate closure of PV-527 (for regeneration circuit)			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	120. Misdirect Flow (cont.)	120.1. Wrong position for any KV in the position between high pressure stream and low pressure stream (cont.)	120.1.2. Natural gas in operating mode (44 barg, 20 °C) routed to NG regeneration module (16 barg) resulting in possible overpressurization, mechanical damage and natural gas leak (possible fire/explosion) (cont.)	120.1.2.4. PSV-530 sized including this scenario			
			120.1.3. Partial loss of natural gas to regeneration/depressurization loop resulting in higher NG flowrate from BL leading to potential loss of efficiency in CO2 and humidity removal with consequent impact on cold box (see relevant node)	120.1.3.1. Valve is FC 120.1.3.2. KV is managed by automatic sequence including discrepancy alarm to freeze the sequence (manual/semi-automatic mode of operation to manage software is not allowed) 120.1.3.3. FAHH-600 activate closure of HV-600 and HV-602 120.1.3.4. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD 120.1.3.5. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	120. Misdirect Flow (cont.)	120.1. Wrong position for any KV in the position between high pressure stream and low pressure stream (cont.)	120.1.3. Partial loss of natural gas to regeneration/depressurization loop resulting in higher NG flowrate from BL leading to potential loss of efficiency in CO2 and humidity removal with consequent impact on cold box (see relevant node) (cont.)	...through ESD			
		120.2. Tube rupture in HW4002	120.2.1. NG (44 barg) enters into HW4002 shell side (DP= 8 barg) and potential overpressuriization on chilled water circuit resulting in mechanical damage and loss of containment of natural gas, potential fire/explosion and injuries to personnel due to mechanical damage	120.2.1.1. PSV-478 sized for this scenario (routed to cold flare)			
		120.3. Unexpected opening of HV-705	120.3.1. Natural gas sent to cold flare with environmental concern	120.3.1.1. Discrepancy alarm on HVs 120.3.1.2. PDAHH-708 activate closure of HV-600 and HV-602	26. Specify FO valve HV-705 since it is blow down valve for emergency purposes	SIAD MI	
			120.3.2. Partial loss of natural gas to cold flare resulting in higher NG flowrate from BL leading to potential loss of efficiency in CO2 and humidity removal with consequent impact on cold box (see relevant node)	120.3.2.1. Discrepancy alarm on HVs 120.3.2.2. PDAHH-708 activate closure of HV-600 and HV-602 (same actions activated by FAHH-600)			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	120. Misdirect Flow (cont.)	120.3. Unexpected opening of HV-705 (cont.)	120.3.2. Partial loss of natural gas to cold flare resulting in higher NG flowrate from BL leading to potential loss of efficiency in CO2 and humidity removal with consequent impact on cold box (see relevant node) (cont.)	120.3.2.3. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD 120.3.2.4. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Temperature Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	121. Lower Temperature	121.1. No causes identified					
More	122. Higher Temperature	122.1. Loss of chilled water to HW4002	122.1.1. Natural gas routed to downstream equipment at 25°C instead of 10°C resulting in reduction of efficiency in liquefaction process	122.1.1.1. TI-485	27. Add a high temperature alarm on TI-485	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Pressure
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	123. Lower Pressure	123.1. Refer to No/Less flow in this node					
		123.2. Low pressure from upstream sections (any cause)	123.2.1. Loss of efficiency in humidity removal resultin in humidity carry over to dowstream section (cold box, see relevant node)	123.2.1.1. PALL-449 activate closure HV-105, HV-106 123.2.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
More	124. Higher Pressure	124.1. PCV-700 malfunction (fully open)	124.1.1. Higher pressure of natural gas routed to analyser (44 barg instead of 1 barg) with potential overpressurization of analysers (AI-1013A, 1012) and associated items (DP= 0.5 barg) with mechanical damage and potential injuries to personnel		28. Ensure provision for pressure release devices to protect analysers AI-1013A, 1012 and associated items in case of wide opening of pressure let down valve PCV-700	SIAD MI	
		124.2. Trapped chilled water in HW4002 shell side	124.2.1. Thermal expansion of trapped chilled water resulting in mechanical damage and economical losses	124.2.1.1. PSV-478 sized for this scenario			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Level
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	125. No/less Level	125.1. Not applicable					
More	126. Higher Level	126.1. Not applicable					

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Intention: HW4002: OTin = 25 °C, OTout = 10 °C
HX7000: OTin = 10 °C, OTout = -168 °C
V4003: OT= 25 °C
Notes: The process includes 8 h of operation and 8 h of bed regeneration (composed by following phases: heating, cooling, pressurization and depressurization)
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Composition
Equipment: V4003, F4005, HW4002, HX7000, HX7001

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	127. Different Composition	127.1. By-pass line left open after maintenance on filter F4005	127.1.1. Possible dust carry over in the downstream section resulting in increased DP on downstream equipment with operational upset	127.1.1.1. Event detectable by PDI-473			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	128. No/less Flow (regeneration gas supply line)	128.1. FIC-461 malfunction closing FV-461 or closure of any KV on regeneration gas loop	128.1.1. Inadequate regeneration resulting in possible slippage of humidity when dryer is put back in service with possible impact on cold box (see relevant node)	128.1.1.1. PDAL-481 128.1.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
			128.1.2. Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire explosion hazard	128.1.2.1. PDALL-481 activate shut-down H4006 128.1.2.2. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			128.1.3. Possible damage to thermal element of H4006 with consequent economical losses	128.1.3.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			128.1.4. Loss of suction feed NG regeneration compressor C5500 resulting in possible mechanical damage and economical losses	128.1.4.1. Recirculating by-pass through PV-505 sized to cope with this scenario 128.1.4.2. PALL-510 activate trip of compressor C5500			Continuous stream from flash vessel is still available to avoid vacuum condition on compressor suction line
	129. No/less Flow (regeneration gas stream)	129.1. Unexpected closure of TV-530A	129.1.1. Inadequate regeneration resulting in possible slippage of humidity when dryer is put back...	129.1.1.1. PDAL-481 129.1.1.2. AI-1013A to...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	129. No/less Flow (regeneration gas stream) (cont.)	129.1. Unexpected closure of TV-530A (cont.)	...in service with possible impact on cold box (see relevant node)	...provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
			129.1.2. Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire explosion hazard	129.1.2.1. PDALL-481 activate shut-down H4006			
				129.1.2.2. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			129.1.3. Possible damage to thermal element of H4006 with consequent economical losses	129.1.3.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			129.1.4. Loss of suction feed NG regeneration compressor C5500 resulting in possible mechanical damage and economical losses	129.1.4.1. Recirculating by-pass through PV-505 sized to cope with this scenario			
				129.1.4.2. PALL-510 activate trip of compressor C5500			
		129.2. Unexpected closure of HV-532 or malfunction of LI-530 closing DV-532	129.2.1. Condensate accumulation in ST5000 leading to level build up and liquid carry over to compressor and potential for mechanical damage leading to economical losses	129.2.1.1. LAHH-531 activate closure of TV-530A			
				129.2.1.2. LAHH-500B activate trip of compressor and close HV-500			

Worksheet

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	130. No/less Flow (depressurization stream)	130.1. Unexpected closure of HV-525 or PV-527 or HV-525 not opening on demand including PT-525 malfunction	130.1.1. Inadequate depressurization of dryer under depressurization leading to freezing of sequence. Possible operational upset overtime (need to shut-down unit after 8 hours)	130.1.1.1. Inconsistent condition alarms generated by sequence (PT-439,440,441)			
			130.1.2. No impact expected on compressor C5500				
	131. No/less Flow (compressor suction)	131.1. Unexpected closure of HV-500	131.1.1. Inadequate regeneration resulting in possible slippage of humidity when dryer is put back in service with possible impact on cold box (see relevant node)	131.1.1.1. PDAL-481 131.1.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
			131.1.2. Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire explosion hazard	131.1.2.1. PDALL-481 activate shut-down H4006 131.1.2.2. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			131.1.3. Possible damage to thermal element of H4006 with consequent economical losses	131.1.3.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			131.1.4. Loss of suction feed...	131.1.4.1. Recirculating...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	131. No/less Flow (compressor suction) (cont.)	131.1. Unexpected closure of HV-500 (cont.)	...NG regeneration compressor C5500 resulting in possible mechanical damage and economical losses	...by-pass through PV-505 sized to cope with this scenario 131.1.4.2. PALL-510 activate trip of compressor C5500			
			131.1.5. Vacuum condition on compressor suction with no impact on mechanical integrity according to design criteria (FV)				
		131.2. Potential plugging of strainer K500NG	131.2.1. Decrease in compressor efficiency and consequent operational upset	131.2.1.1. Differential pressure gauge provided for K500NG (see dedicated P&ID for compressor C5500)			
		131.3. Unexpected compressor stop (any cause)	131.3.1. Inadequate regeneration resulting in possible slippage of humidity when dryer is put back in service with possible impact on cold box (see relevant node)	131.3.1.1. PDAL-481 131.3.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
			131.3.2. Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel...	131.3.2.1. PDALL-481 activate shut-down H4006 131.3.2.2. TAHH-466/467 activate trip of heater...			

Worksheet

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	131. No/less Flow (compressor suction) (cont.)	131.3. Unexpected compressor stop (any cause) (cont.)	...injuries/fire explosion hazard	...H4006 (same actions activated by TAHH-469)			
			131.3.3. Possible damage to thermal element of H4006 with consequent economical losses	131.3.3.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
		131.4. Malfunction of PIC-500 reducing speed of compressor motor	131.4.1. See consequences for stop of compressor but less critical				
	132. No/less Flow (compressor discharge)	132.1. Plugging of compressor post filter F5501	132.1.1. Increased DP accross filter with operational upset	132.1.1.1. Differential pressure gauge provided for F5501 (see dedicated P&ID for compressor C5500)			
		132.2. Unexpected closure of HV-504	132.2.1. See consequences of unexpected closure of HV-500 for impact on upstream section				
			132.2.2. Pressure build up on compressor discharge system (DP=49 barg) and possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel	132.2.2.1. PIC-504 to open PV-505 132.2.2.2. PAHH-511 activate trip of compressor 132.2.2.3. PSV-503			Each stage is provided with PSV sized for blocked outlet (PSV-501/502) and high high pressure interlock (PAHH-501/502)
		132.3. Unexpected closure of HV-511	132.3.1. Unavailability of bleed valve on demand		29. Specify HV-511 as FO valve	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	133. More Flow	133.1. Malfunction of FIC-461 fully opening FV-461	133.1.1. Increased fllowrate through H4006 leading to possible inadequate heating up of regeneration gas resulting in potential uncomplete regeneration (possible humidity slippage when the dryer is put back in service and impact on cold box, see relevant node)	133.1.1.1. TAL-483 133.1.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration through ESD			
			133.1.2. Pressure build up on C5500 suction resulting in possible mechanical damage and economical losses	133.1.2.1. PAH-531, PAH-500 133.1.2.2. PAHH-510 activate trip of compressor 133.1.2.3. PAHH-531 activate closure of TV-530A			
		133.2. Malfunction of PIC/HIC-525 opening PV-525 more than required	133.2.1. Excessive depressurization rate for involved dryer resulting in possible reduction in lifetime of internals of absorption bed with economical losses	133.2.1.1. PAH-528			
			133.2.2. Pressure build up on C5500 suction resulting in possible mechanical damage and economical losses	133.2.2.1. PAH-500 133.2.2.2. PAHH-510 activate trip of compressor 133.2.2.3. PAHH-528 activate closure of PV-527			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow   Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	133. More Flow (cont.)	133.3. Malfunction of compressor control (PIC-500) system increasing motor speed through VFD	133.3.1. No impact on usptream section				
			133.3.2. Lower pressure on compressor suction side with possible compressor motor overload leading to damage to motor (economical losses)	133.3.2.1. Overload protection for compressor motor activate trip of compressor motor 133.3.2.2. PALL-510 activate trip of compressor motor			
Reverse	134. Reverse Flow	134.1. Compressor trip/stop (any cause)	134.1.1. Reverse flow from compressor discharge system (43 barg) toward compressor suction side (DP=8 barg for ST5000 and HW5000) has not been considered a credible scenario since compressor is reciprocating type and any cause of compressor trip/stop will lead to closure of HV-504, HV-500 and opening HV-505 (by-bass line through PV-505 is normally closed during normal operation)				
Misdirect	135. Misdirect Flow	135.1. Unexpected opening of HV-455/HV-535	135.1.1. Natural gas sent to cold flare with environmental concern	135.1.1.1. HV-455/HV-535 is FC and managed by depressurization/purging sequence 135.1.1.2. Discrepancy alarm on HVs			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	135. Misdirect Flow (cont.)	135.1. Unexpected opening of HV-455/HV-535 (cont.)	135.1.2. Loss of suction feed NG regeneration compressor C5500 resulting in possible mechanical damage and economical losses	135.1.2.1. HV-455/HV-535 is FC and managed by depressurization/purging sequence 135.1.2.2. Recirculating by-pass through PV-505 sized to cope with this scenario 135.1.2.3. PALL-510 activate trip of compressor C5500			
		135.2. Unexpected opening of HV-464	135.2.1. Limited amount of natural gas sent to cold flare (amount involved in depressurization) with minor environmental concern	135.2.1.1. HV-464 is FC and managed by depressurization/purging sequence 135.2.1.2. Discrepancy alarm on HVs			
		135.3. Unexpected opening of HV-539	135.3.1. Nitrogen entrainment on depressurization gas stream routed to compressor suction side with increased content of nitrogen in process flow (minor operational upset)	135.3.1.1. Discrepancy alarm on HVs			
			135.3.2. Nitrogen entrainment on depressurization gas stream with pressure build up on C5500 suction resulting in possible mechanical damage and...	135.3.2.1. HV-539 is FC and managed by depressurization/purging sequence			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	135. Misdirect Flow (cont.)	135.3. Unexpected opening of HV-539 (cont.)	...economical losses	135.3.2.2. Discrepancy alarm on HVs 135.3.2.3. PAH-500 135.3.2.4. PAHH-510 activate trip of compressor C5500			
			135.3.3. After compressor shut down pressure build up (OPof nitrogen =9barg) on blocked in suction system (DP=10 barg) with no mechanical impact 135.3.4. Nitrogen at 9 barg routed to flash vessel S1003 with no impact on mechanical integrity according to design criteria (DP=10 barg for vessel and 16 barg for associated piping)				
		135.4. Unexpected opening of TV-530B	135.4.1. During dryer heating mode, higher temperature of natural gas to downstream section (220°C instead of 10°C) due to by-pass of HW5000, with possible overheating (DT=65°C for EW5000) resulting in mechanical damage and possible leak of natural gas with possible fire		30. Add a high high temperature interlock initiated by TI-535 to close TV-530B	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	135. Misdirect Flow (cont.)	135.5. Tube rupture in HW5000	135.5.1. Chilled water (OP approximately 3 barg) enters into regeneration gas stream with possible liquid accumulation on ST5000 leading to level build up and liquid carry over to compressor and potential for mechanical damage leading to economical losses	135.5.1.1. LAHH-500B activate trip of compressor and close HV-500			
			135.5.2. In case of possible natural gas entrainment in chilled water circuit no significant consequences are expected during normal operation; accumulation of natural gas can lead to potential exposure of maintenance operator to flammable mixture		31. Maintenance procedure for chilled water circuit shall include actions and safeguards to avoid personnel exposure to natural gas possibly present	OSE (TZSA)	
		135.6. Unexpected opening of HV-505	135.6.1. Natural gas sent to cold flare with environmental concern	135.6.1.1. Discrepancy alarm on HVs			
			135.6.2. Loss of regeneration gas stream to natural gas feed stream with no impact				
		135.7. Inadvertent opening of separators drain valve	135.7.1. Potential operational upset due to unexpected trip of compressor due to PALL intervention/leakage of NG and potential for personnel exposure to fire/explosion hazards		32. Specify manual valves on recycle gas compressor separators drains as LC	SIAD MI	

Worksheet

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	135. Misdirect Flow (cont.)	135.8. Malfunction of PIC-500/PIC-504 opening PV-505 when not required	135.8.1. Pressure build up on C5500 suction (DP=6 barg) resulting in possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel	135.8.1.1. PAHH-510 activate trip of compressor			

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	136. Lower Temperature	136.1. Failure of H4006 including TI-483 malfunction	136.1.1. Lower temperature of regeneration gas leading to inadequate regeneration resulting in possible slippage of humidity when dryer is put back in service with possible impact on cold box (see relevant node)	136.1.1.1. Discrepancy alarm provided by sequence if required temperature is not reached at the end of heating phase (TI-430-438) 136.1.1.2. AI-1013A to provide a high H2O concentration alarm and to close HV-700 on high high H2O concentration...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	136. Lower Temperature (cont.)	136.1. Failure of H4006 including TI-483 malfunction (cont.)	136.1.1. Lower temperature of regeneration gas leading to inadequate regeneration resulting in possible slippage of humidity when dryer is put back in service with possible impact on cold box (see relevant node) (cont.)	...through ESD			
		136.2. TV-530B does not open on demand including TAL-532 malfunction	136.2.1. Possible freezing of collected water in ST5000 resulting in possible damage of associated items (e.g. bottom drain valve) with no safety concern	136.2.1.1. Gas is passing through HW5000 (operated with chilled water at 5°C) 136.2.1.2. Electrical tracing provided for ST5000 and bottom drain lines			Low temperature scenario is expected only in the beginning of heating phase for limited period of time (few minutes)
		136.3. Loss of steam to EW5000 including TIC-555 malfunction closing TV-555	136.3.1. Regeneration gas routed to compressor C5500 at 10°C instead of 35°C with possible minor operational upset due to unstable operation conditions for compressor	136.3.1.1. TALL-535 activate closure of PV-527, TV-530A, TV-530B			
			136.3.2. Possible freezing on water bath in EW5000 resulting in possible damage (economical losses)	136.3.2.1. TALL-556 activate closure of PV-527, TV-530A, TV-530B			Low temperature scenario is expected only in the beginning of heating phase for limited period of time (few minutes)
		136.4. Low ambient temperature	136.4.1. Possible freezing of stagnant piping on water side	136.4.1.1. Electrical tracing and insulation provided on water piping (electrical...	:See 8		

Worksheet

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	136. Lower Temperature (cont.)	136.4. Low ambient temperature (cont.)	136.4.1. Possible freezing of stagnant piping on water side (cont.)	...tracing also supplied by EDG)	:See 8 (cont.)		
More	137. Higher Temperature	137.1. See no/less flow (overheating of H4006)					
		137.2. Failure of TI-483 leading to higher heat input in H4006	137.2.1. Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire explosion hazard	137.2.1.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
			137.2.2. Possible damage to thermal element of H4006 with consequent economical losses	137.2.2.1. TAHH-466/467 activate trip of heater H4006 (same actions activated by TAHH-469)			
		137.3. Inadequate cooling of dryer after regeneration (KV failure in close position)	137.3.1. When dryer is put back in service transient higher temperature of process gas to downstream unit is expected with potential operational upset/thermal stress for HX-7000	137.3.1.1. KV is managed by automatic sequence including discrepancy alarm (on temperature, time and on valve position) to freeze the sequence (manual/semi-automatic mode of operation to manage software is not allowed)			
				137.3.1.2. TAHH-701 to activate closure of HV-700			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	137. Higher Temperature (cont.)	137.3. Inadequate cooling of dryer after regeneration (KV failure in close position) (cont.)	137.3.2. When dryer is put back in service transient higher temperature of process gas to downstream unit and potential overheating of F4005 (DT=100°C) resulting in mechanical damage and possible leak of natural gas with possible fire	137.3.2.1. KV is managed by automatic sequence including discrepancy alarm (on temperature, time and on valve position) to freeze the sequence (manual/semi-automatic mode of operation to manage software is not allowed)			
		137.4. See misdirected flow (opening of TV-530B)					
		137.5. Loss of chilled water supply to HW5000	137.5.1. During dryer heating mode, higher temperature of natural gas to downstream section (220°C instead of 10°C) with possible overheating (DT=65°C for EW5000) resulting in mechanical damage and possible leak of natural gas with possible fire	137.5.1.1. TAHH-532 activate closure of TV-530A			
		137.6. Malfunction of TIC-555 fully opening TV-555	137.6.1. Higher temperature (up to 100°C) of regeneration gas to compressor resulting in possible overheating of EW5000 process gas coils (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		33. Review design temperature of EW5000 process gas coils up to 100°C	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	137. Higher Temperature (cont.)	137.7. Loss of cooling water to HW5501	137.7.1. Higher temperature of natural gas to second stage of compressor resulting in potential damage to internals and consequent economical losses	137.7.1.1. TAHH-502 activate trip of compressor			
		137.8. Loss of cooling water to HW5502	137.8.1. Higher temperature of natural gas to third stage of compressor resulting in potential damage to internals and consequent economical losses	137.8.1.1. TAHH-503 activate trip of compressor			
		137.9. Loss of cooling water to HW5503	137.9.1. Higher temperature of natural gas (estimated approximately 137°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		34. Add a high high temperature interlock downstream HW5503 to activate trip of compressor C5500	SIAD MI	
			137.9.2. No impact on natural gas feed due to increased temperature of recycled gas stream due to limited flowrate from compressor				

Worksheet

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Pressure
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	138. Lower Pressure	138.1. Rerer to No/Less and Misdirect Flow					
		138.2. Shut down of steam supply to EW5000 coil	138.2.1. Possible vacuum condition with no impact on mechanical integrity according to design criteria				
More	139. Higher Pressure	139.1. Refer to No/Less and Misdirect Flow					
		139.2. Trapped chilled water in HW5000 shell side	139.2.1. Thermal expansion of trapped chilled water resulting in mechanical damage and economical losses	139.2.1.1. PSV-550 sized for this scenario			

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	140. No/less Level	140.1. Malfunction of LIC-530 not closing DV-532 on demand	140.1.1. Natural gas at 2 barg routed to S2011 with no impact on mechanical integrity according to design criteria (DP=2 barg)				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level   Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	140. No/less Level (cont.)	140.1. Malfunction of LIC-530 not closing DV-532 on demand (cont.)	140.1.2. Partial loss of regeneration gas to S2011 and in turns to thermal oxidizer through PV-275 with minor economical losses	140.1.2.1. LALL-531 activate closure of HV-532			
			140.1.3. Partial loss of regeneration gas to S2011 resulting in reduced flowrate to compressor leading to partial loss of suction feed NG regeneration compressor C5500 with possible mechanical damage and economical losses	140.1.3.1. LALL-531 activate closure of HV-532 140.1.3.2. Recirculating by-pass through PV-505 sized to cope with this scenario 140.1.3.3. PALL-510 activate trip of compressor C5500			
		140.2. Malfunction of LSL-545 not opening LV-545 on demand	140.2.1. Inadequate water make up to EW5000 leading to loss of level and consequent loss of duty to regeneration gas stream (see lower temperature due to loss of steam to EW5000)	140.2.1.1. TAL-535			
		140.3. Malfunction of LIC-500A not closing DV-500 on demand	140.3.1. Natural gas at 2 barg routed to S2011 with no impact on mechanical integrity according to design criteria (DP=2 barg)				
			140.3.2. Partial loss of regeneration gas to S2011 and in turns to thermal oxidizer through PV-275 with minor economical...	140.3.2.1. LALL-500B activate closure of HV-515			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	140. No/less Level (cont.)	140.3. Malfunction of LIC-500A not closing DV-500 on demand (cont.)	...losses	140.3.2.1. LALL-500B activate closure of HV-515 (cont.)			
			140.3.3. Partial loss of regeneration gas to S2011 resulting in reduced flowrate to compressor leading to partial loss of suction feed NG regeneration compressor C5500 with possible mechanical damage and economical losses	140.3.3.1. LALL-500B activate closure of HV-515 140.3.3.2. Recirculating by-pass through PV-505 sized to cope with this scenario 140.3.3.3. PALL-510 activate trip of compressor C5500			
		140.4. Malfunction of LIC-501A not closing DV-501 on demand	140.4.1. Natural gas at 4.9 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire	140.4.1.1. LALL-501B activate closure of HV-515	35. Investigate additional safeguard to prevent overpressurization in S2011 in case of gas breakthrough from C5500 compressor separators (e.g. PSV routed to cold flare located downstream HV-515, additional PAHH on drain line to S2011 acting on additional on/off valve etc..)	SIAD MI	
			140.4.2. No impact on compressor				
		140.5. Malfunction of LIC-502A not closing DV-502 on demand	140.5.1. Natural gas at 15 barg routed to S2011 (DP=2 barg)...	140.5.1.1. LALL-502B activate closure of HV-515	:See 35		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	140. No/less Level (cont.)	140.5. Malfunction of LIC-502A not closing DV-502 on demand (cont.)	...with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire	140.5.1.1. LALL-502B activate closure of HV-515 (cont.)	:See 35 (cont.)		
			140.5.2. No impact on compressor				
		140.6. Malfunction of LIC-503A not closing DV-503 on demand	140.6.1. Natural gas at 43 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire	140.6.1.1. LALL-503B activate closure of HV-515	:See 35		
			140.6.2. No impact on compressor				
More	141. Higher Level	141.1. See No/Less and Misdirect Flow for level build up in ST5000					
		141.2. Malfunction of LSH-545 opening LV-545 when not required	141.2.1. Level build up in EW5000 resulting in overfilling and water carry over to drain collection pit at grade. Waste of water with no impact on personnel safety	141.2.1.1. TAL-556			
			141.2.2. Level build up in EW5000 resulting in overfilling ...	141.2.2.1. TAL-535/TAL-556			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	141. Higher Level (cont.)	141.2. Malfunction of LSH-545 opening LV-545 when not required (cont.)	...and continuous water circulation through overflow line leading to lower temperature of recycling gas to compressor (see low temperature for loss of steam but less critical)	141.2.2.1. TAL-535/TAL-556 (cont.)			
		141.3. Malfunction of LIC-500A not opening DV-500 on demand	141.3.1. Condensate accumulation in ST5500 leading to level build up and possible liquid carry over to compressor first stage and potential for mechanical damage leading to economical losses	141.3.1.1. LAHH-500B activate trip of compressor and close HV-500			
		141.4. Malfunction of LIC-501A not opening DV-501 on demand	141.4.1. Condensate accumulation in ST5501 leading to level build up and possible liquid carry over to compressor second stage and potential for mechanical damage leading to economical losses	141.4.1.1. LAHH-501B activate trip of compressor and close HV-500			
		141.5. Malfunction of LIC-502A not opening DV-502 on demand	141.5.1. Condensate accumulation in ST5502 leading to level build up and possible liquid carry over to compressor third stage and potential for mechanical damage leading to economical losses	141.5.1.1. LAHH-502B activate trip of compressor and close HV-500			
		141.6. Malfunction of LIC-503A not opening DV-503 on demand	141.6.1. Condensate accumulation in ST5503 leading...				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	141. Higher Level (cont.)	141.6. Malfunction of LIC-503A not opening DV-503 on demand (cont.)	...to level build up and possible liquid carry over to natural gas feed with negligible impact				
			141.6.2. In case compressor is operated in recycling mode (e.g. start up operation) possible condensate accumulation in ST5503 leading to level build up and possible liquid carry over to compressor first stage through PV-505 and potential for mechanical damage leading to economical losses	141.6.2.1. LAHH-503B activate trip of compressor			

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Composition Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	142. Different Composition	142.1. By-pass of NG regeneration gas compressor post-filter F5501 left open after maintenance	142.1.1. Possible carry over of piston ring wear material to NG feed with negligible impact				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Intention: H4006: OTin = 0,9 °C , OTout = 250 °C
V4005: OT= 250 / 10 °C
EW5000: OTin = 10 °C, OTout = 35 °C
C5500: OPsuction = 2,55 barg , OPdischarge = 44,5 barg
V4004: OT= 25 °C
Notes:
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Services / Utilities
Equipment: H4006, V4004, V4005, HW5000, ST5000, EW5000, C5500

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	143. No Services / Utilities	143.1. No additional cause identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow — Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	144. No/less Flow	144.1. No/Less flow from upstream section	144.1.1. No impact on this node				
		144.2. Malfunction of FIC-713 closing FV-713	144.2.1. No impact on this node and upstream system (pressure build up is not expected, however all natural gas loop from metering station let down valve to JT valve PV-703 is designed at same value (52 barg))				
			144.2.2. Loss of LNG production and potential interruption of truck loading operation	144.2.2.1. LI-1901A/B on LNG storage tank including low level alarms			
		144.3. Malfunction of PIC-703 closing PV-703 (JT valve)	144.3.1. No impact on this node and upstream system (pressure build up is not expected, however all natural gas loop from metering station let down valve to JT valve PV-703 is designed at same value (52 barg))				
			144.3.2. Loss of LNG production and potential interruption of truck loading operation	144.3.2.1. LI-1901A/B on LNG storage tank including low level alarms			
		144.4. Malfunction of PIC-715A closing PV-715	144.4.1. Inadequate displacement of not condensable gas and consequent accumulation resulting in pressure build up in LNG separator S7003 (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages inside the cold box...	144.4.1.1. PAHH-717 activate closure of HV-700 144.4.1.2. PSV-705 sized including this scenario			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	144. No/less Flow (cont.)	144.4. Malfunction of PIC-715A closing PV-715 (cont.)	...with release of NG to atmosphere through cold box vent valve (no impact on personnel expected since breathing valve vent located at safe location). Possible operational disruption due to equipment damage and prolonged maintenance operation	144.4.1.2. PSV-705 sized including this scenario (cont.)			
			144.4.2. Inadequate displacement of not condensable gas and consequent accumulation resulting in pressure build up in LNG separator S7003 (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages inside the cold box with potential cold box overpressurization, mechanical damage and injuries to personnel (fire/explosion hazard)	144.4.2.1. PAHH-717 activate closure of HV-700 144.4.2.2. PSV-705 sized including this scenario 144.4.2.3. Overpressure device provided on cold box			
		144.5. Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV-1913A/B	144.5.1. Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment	144.5.1.1. LAHH-716 activate closure HV-700 144.5.1.2. TALL-915 activate closure HV-721			
			144.5.2. Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with consequent vaporization resulting in...	144.5.2.1. LAHH-716 activate closure of HV-700 (same actions activated by PAHH-717)			

Session: (4) 30/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	144. No/less Flow (cont.)	144.5. Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV-1913A/B (cont.)	...pressure build up in LNG separator S7003 (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages inside the cold box with release of NG to atmosphere through cold box vent valve (no impact on personnel expected since breathing valve vent located at safe location). Possible operational disruption due to equipment damage and prolonged maintenance operation	144.5.2.2. PSH-715A activate opening HV-715 to cold flare KO drum V16000 144.5.2.3. PSV-705 sized including this scenario			
			144.5.3. Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with consequent vaporization resulting in pressure build up in LNG separator S7003 (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages inside the cold box with potential cold box overpressurization, mechanical damage and injuries to personnel (fire/explosion hazard)	144.5.3.1. LAHH-716 activate closure of HV-700 (same actions activated by PAHH-717) 144.5.3.2. PSH-715A activate opening HV-715 to cold flare KO drum V16000 144.5.3.3. PSV-705 sized including this scenario 144.5.3.4. Overpressure device provided on cold box			
			144.5.4. Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with consequent vaporization resulting in pressure build up in EW9000 and...	144.5.4.1. LAHH-716 activate closure of HV-700 (same actions activated by PAHH-717) 144.5.4.2. PSH-715A...	36. PSV-914 shall be verified for LNG vaporization in EW9000	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow　　Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	144. No/less Flow (cont.)	144.5. Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV-1913A/B (cont.)	...associated piping (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages with possible injuries to personnel (fire/explosion hazard)	...activate opening HV-715 to cold flare KO drum V16000 144.5.4.3. Overpressure device provided on cold box	36. PSV-914 shall be verified for LNG vaporization in EW9000 (cont.)		
More	145. More Flow	145.1. Malfunction of FIC-713 opening FV-713	145.1.1. No significant impact (flowrate on NG, LNG system is managed by JT valve PV-703)				
		145.2. See pressure parameter for wide opening of PV-703					
Reverse	146. Reverse Flow	146.1. Shut-down of thermal oxidizer	146.1.1. Possible CO2 stream at 0,9 barg (from S2011) back flow from V16200 to LNG separator S7003 (OP = 0,5 barg) leading to possible LNG contamination and off spec products		37. PAHH-1640 shall close HV-1646 to avoid LNG contamination by CO2 in case of thermal oxidizer shut-down possibly leading to CO2 backflow from V16200 to LNG separator S7003	SIAD MI	
Misdirect	147. Misdirect Flow	147.1. HV-701 stuck in open position after start-up	147.1.1. Negligible impact according to limited size of HV-701				
		147.2. Unexpected opening of HV-715	147.2.1. Possible continuous NG routed to cold flare with environmental concern and loss of product		38. Provide alarm on HZI-715 for loss of closed position of HV-715	SIAD MI	
			147.2.2. Pressure decrease in S7003 and consequent loss of driving force for LNG displacement to storage tank...		:See 38		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	147. Misdirect Flow (cont.)	147.2. Unexpected opening of HV-715 (cont.)	...resulting in level build up in S7003 (see no/less flow for overfilling in S7003 and consequent overpressurization)		:See 38 (cont.)		
			147.2.3. Pressure decrease in S7003 and consequent loss of driving force for LNG displacement to storage tank resulting in level build up in S7003 and consequent possible overfilling leading to possible LNG carry over to cold flare KO drum V16000 resulting in operational upset (vaporization of LNG on cold flare header will lead to fluctuation in separator pressure and discontinuous discharge to tank)	147.2.3.1. LAHH-716 activate closure HV-700			
		147.3. Unexpected opening of HV-711	147.3.1. LNG routed to cold flare KO drum V16000 resulting in KO drum overfilling and possible liquid carry over to cold flare resulting in LNG outflow from flare tips with potential injuries to personnel	147.3.1.1. Discrepancy alarm on HVs	39. Add a high high level interlock on V16000 to activate closure of HV-700 (relevant set point to be defined to allow adequate residual volume preventing overfilling after HV-700 closure)	SIAD MI	
		147.4. Unexpected opening of HV-916	147.4.1. Not condensable gas routed to cold flare instead of to thermal oxidizer leading to minor environmental concern	147.4.1.1. Valve is FC and has discrepancy alarm on HVs			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Temperature   Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	148. Lower Temperature	148.1. Loss of LP steam in EW9000 including malfunction of TIC-952 closing TV-952	148.1.1. Natural gas routed to thermal oxidizer inlet line at -168°C instead of 20°C with possible embrittlement of piping resulting in mechanical and injuries to personnel (fire/explosion hazard)	148.1.1.1. TALL-915 activate closure HV-721			
			148.1.2. Freezing in EW9000 is not expected due to limited flowrate of cryogenic gas and continuous circulation of water through EW9000				
		148.2. Low ambient temperature	148.2.1. Possible freezing of stagnant piping on water side of EW9000	148.2.1.1. Electrical tracing and insulation provided on water piping (electrical tracing also supplied by EDG)	:See 8		
More	149. Higher Temperature	149.1. Higher temperature of natural gas from upstream section (see high temperature in node #9)					
		149.2. See higher temperature from node #10 (Inadequate cooling of dryer after refeneration (KV failure in close position))					
		149.3. Loss of cooling duty from primary heat exchanger HX7000 (any cause related to nodes #30 and #31)	149.3.1. Loss of cooling medium circulation through HX7000 with partial loss of LNG production (operation disruption/economical losses)	149.3.1.1. Event detectable by TI-705 149.3.1.2. Monitoring instrumentation provided...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Temperature Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	149. Higher Temperature (cont.)	149.3. Loss of cooling duty from primary heat exchanger HX7000 (any cause related to nodes #30 and #31) (cont.)	149.3.1. Loss of cooling medium circulation through HX7000 with partial loss of LNG production (operation disruption/economical losses) (cont.)	...on cooling media (see nodes #30 and #31)			
		149.4. Loss of duty in LNG subcooler SC7001 (See any cause related to node #31)	149.4.1. Loss of cooling medium circulation through SC7001 with partial loss of LNG production (operation disruption/economical losses)	149.4.1.1. Event detectable by TI-718 149.4.1.2. Monitoring instrumentation provided on LNG subcooler SC7001 (see node #31)			
		149.5. Malfunction of TIC-952 fully opening TV-952 on LP steam to EW9000	149.5.1. Abnormal input to EW9000 resulting in increased temperature (max estimated < 90°C) of gas routed to thermal oxidizer with no impact				
			149.5.2. Higher temperature of water bath in EW9000 (max 100°C) with no impact on EW9000 and coils according to selected material (stainless steel)		40. Review design temperature of EW9000 from 90°C to 100°C	SIAD MI	
			149.5.3. Higher temperature of water bath in EW9000 leading to steam generation and consequent possible release from EW9000 atmospheric vent and potential injuries to personnel	149.5.3.1. TAH-953	41. Ensure safe location requirements of EW5000 and EW9000 atmospheric vent	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Pressure Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	150. Lower Pressure	150.1. Refer to No/Less Flow in this node					
		150.2. Refer to Misdirect flow (opening of HV-715)					
		150.3. Malfunction of PIC-715 opening PV-715 when not required	150.3.1. Pressure decrease in S7003 and consequent loss of driving force for LNG displacement to storage tank resulting in level build up in S7003 (see no/less flow for overfilling in S7003 and consequent overpressurization)				
More	151. Higher Pressure	151.1. Refer to No/Less Flow in this node					
		151.2. Malfunction of PIC-703 fully opening PV-703	151.2.1. LNG at 43 barg sent to LNG separator S7003 and associated piping (DP= 16 barg) leading to potential overpressurization, mechanical damage with possible operational disruption due to equipment damage and prolonged maintenance operation	151.2.1.1. PSH-715A activate opening HV-715 to cold flare KO drum V16000 (sized for JT valve PV-703 wide opening) 151.2.1.2. PAHH-717 activate closure of HV-700 151.2.1.3. PSV-705 sized including this scenario			
			151.2.2. LNG at 43 barg sent to LNG separator S7003 and associated piping (DP= 16 barg) leading to potential for LNG leakages inside the cold box with potential cold box...	151.2.2.1. PSH-715A activate opening HV-715 to cold flare KO drum V16000 (sized for JT valve PV-703 wide opening)			

Worksheet

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Pressure
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	151. Higher Pressure (cont.)	151.2. Malfunction of PIC-703 fully opening PV-703 (cont.)	...overpressurization, mechanical damage and injuries to personnel (fire/explosion hazard)	151.2.2.2. PAHH-717 activate closure of HV-700 151.2.2.3. PSV-705 sized including this scenario 151.2.2.4. Overpressure hatch on cold box			
		151.3. External fire/Thermal expansion	151.3.1. Overpressurization of involved equipment/piping with possible mechanical damage	151.3.1.1. All isolatable equipment and piping on LNG sections are protected by pressure relief devices sized for this case	:See 7		

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Level
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	152. No/less Level	152.1. Malfunction of LIC-715 fully opening LV-715	152.1.1. Loss of level in S7003 and consequent gas brekthrough (0,5 barg) to LNG VT19000 and VT19001 (DP=5barg) with no impact on mechanical integrity according to design criteria				
			152.1.2. Loss of level in S7003 and consequent gas breakthrough (0,5 barg), involving not condensable gases to LNG VT19000 and VT19001...	152.1.2.1. LALL-716 activate closure of HV-717			

Worksheet

Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Level
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	152. No/less Level (cont.)	152.1. Malfunction of LIC-715 fully opening LV-715 (cont.)	...(DP=5barg) resulting in uncondensable gas accumulation into BOG and relevant circuit and consequent operational upset overtime due to unstable operations	152.1.2.1. LALL-716 activate closure of HV-717 (cont.)			
		152.2. Malfunction of LSL-940 not opening LV-940 on demand	152.2.1. Inadequate water make up to EW9000 leading to loss of level and consequent loss of duty to regeneration gas stream (see lower temperature due to loss of steam to EW9000)				
More	153. Higher Level	153.1. Refer to No/Less and misdirect flow					
		153.2. Refer to low pressure					
		153.3. Malfunction of LSH-940 opening LV-940 when not required	153.3.1. Level build up in EW9000 resulting in overfilling and water carry over to drain collection pit at grade. Waste of water with no impact on personnel safety	153.3.1.1. TAL-953			
			153.3.2. Level build up in EW9000 resulting in overfilling and continuous water circulation through overflow line leading to lower temperature of cryogenic gas to thermal oxidizer (see low temperature for loss of steam but less critical)	153.3.2.1. TAL-953			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Composition
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	154. Different Composition	154.1. Presence of humidity/CO_2 due to upset on upstream treatment sections (See nodes relevant to CO_2 removal and to gas drying)	154.1.1. Freezing of water and/or CO_2 inside LNG coils of primary heat eschanger HX7000 resulting in plugging leading to reduction/loss of LNG production overtime. No safety concern	154.1.1.1. See dedicated safeguards provided on upstream section and dedicated to prevent slippage of CO_2 and humidity (see relevant nodes) 154.1.1.2. AI-1012 to provide a high CO_2 concentration alarm and to close HV-700 on high high CO_2 concentration through ESD 154.1.1.3. AI-1013A to provide a high H_2O concentration alarm and to close HV-700 on high high H_2O concentration through ESD			
		154.2. See no/less flow and lower level for inadequate displacement of not condensable gas (N_2, H_2, O_2)					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Intention: S7003: OT = -166,53 °C
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes:
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Services / Utilities
Equipment: S7003, EW9000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	155. No Services / Utilities	155.1. No additional cause identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	156. No/less Flow	156.1. Unexpected closure of PV1910A (including PIC1910A malfunction) or unexpected closure of additional HV provided at liquid outlet from tank connected to BOG system	156.1.1. Low pressure on LNG storage tanks VT19000 and VT19001 (see node #13)				Additional HV will be provided on each tank liquid outlet to LNG build-up vaporizer
			156.1.2. No impact expected on BOG compressor since when build-up vaporizer is required in operation, compressor is not foreseen to suct build up gas from tank VT19000				
		156.2. Unexpected closure of PV1910B (including PIC1910B malfunction) or unexpected closure of HV939 or unexpected closure of HV900	156.2.1. High pressure on LNG storage tanks VT19000 and VT19001 (see node #13)				
			156.2.2. Blocked outlet condition for truck loading BOG line only in case of closure oh HV-900 (See No/Less Flow in node #13 due to closure of FV-914)				
			156.2.3. Reduced BOG feed to BOG compressor C9100 / Loss of BOG feed to BOG compressor C9100 (when truck loading is not in place) resulting in possible mechanical damage and economical losses	156.2.3.1. Recirculating by-pass through PV-905 sized to cope with this scenario 156.2.3.2. PALL-910 activate trip of compressor C9100			
			156.2.4. No impact on NG feed due to loss of BOG recovery stream (less than 5% of feed)				

Worksheet

Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	156. No/less Flow (cont.)	156.3. Potential plugging of strainer K900NG	156.3.1. Decrease in compressor efficiency and consequent operational upset	156.3.1.1. Differential pressure gauge provided for K900NG (see dedicated P&ID for compressor C9100)			
		156.4. Compressor C9100 failure	156.4.1. High pressure on LNG storage tanks VT19000 and VT19001 (see node #13)				
			156.4.2. Blocked outlet condition for truck loading BOG line (See No/Less Flow in node #13 due to closure of FV-914)				
			156.4.3. No impact on NG feed due to loss of BOG recovery stream (less than 5% of feed)				
		156.5. Malfunction of compressor control system (PIC-900/PIC-904) reducing compressor motor speed to VFD	156.5.1. High pressure on LNG storage tanks VT19000 and VT19001 (see node #13)				
			156.5.2. Blocked outlet condition for truck loading BOG line (See No/Less Flow in node #13 due to closure of FV-914)				
			156.5.3. No impact on NG feed due to loss of BOG recovery stream (less than 5% of feed)				
	157. No/less Flow (compressor discharge)	157.1. Plugging of compressor post filter F9101	157.1.1. Increased DP accross filter with operational upset	157.1.1.1. Differential pressure gauge provided...			

Worksheet

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	157. No/less Flow (compressor discharge) (cont.)	157.1. Plugging of compressor post filter F9101 (cont.)	157.1.1. Increased DP accross filter with operational upset (cont.)	...for F9101 (see dedicated P&ID for compressor C9100)			
		157.2. Unexpected closure of HV-904	157.2.1. No impact on NG feed due to loss of BOG recovery stream (less than 5% of feed)				
			157.2.2. Pressure build up on LNG storage tanks VT19000 and VT19001 (see node #13)				
			157.2.3. Pressure build up on compressor discharge system (DP=49 barg) and possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel	157.2.3.1. PIC-904 to open PV-905 157.2.3.2. PAHH-911 activate trip of compressor 157.2.3.3. PSV-903			Each stage is provided with PSV sized for blocked outlet (PSV-901/902) and high high pressure interlock (PAHH-901/902)
More	158. More Flow	158.1. Malfunction of compressor control system (PIC-900/PIC-904) increasing compressor motor speed to VFD	158.1.1. No impact on usptream section				
			158.1.2. Lower pressure on compressor suction side with possible compressor motor overload leading to damage to motor (economical losses)	158.1.2.1. Overload protection for compressor motor activate trip of compressor motor 158.1.2.2. PALL-910 activate trip of compressor motor			
			158.1.3. No impact on NG feed...				

Worksheet

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	158. More Flow (cont.)	158.1. Malfunction of compressor control system (PIC-900/PIC-904) increasing compressor motor speed to VFD (cont.)	...due to transient increase of BOG recovery stream (less than 5% of feed)				
Reverse	159. Reverse Flow	159.1. Compressor trip/stop (any cause)	159.1.1. Reverse flow from compressor discharge system (OP=43 barg) toward compressor suction side (DP=5 barg for VT19000 and VT19001) has not been considered a credible scenario since compressor is reciprocating type and any cause of compressor trip/stop will lead to closure of HV-904, HV-900 and opening HV-905 (by-bass line through PV-905 is normally closed during normal operation)				
Misdirect	160. Misdirect Flow	160.1. PV-1910A suck in open position during compressor in operation (PV-1910B opened)	160.1.1. Transient slight pressure build up on LNG storage tanks VT19000 and VT19001				
			160.1.2. Increased BOG flowrate through EW9000 coil and consequent lower temperature on downstream piping with possible embrittlement of piping leading to mechanical damage and loss of containment with possible fire/explosion hazard	160.1.2.1. TALL-913 activate closure of HV-939			
			160.1.3. Increased LNG...	160.1.3.1. TALL-913...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	160. Misdirect Flow (cont.)	160.1. PV-1910A suck in open position during compressor in operation (PV-1910B opened) (cont.)	...circulation through build up vaporizer E1900 leading to ice formation and inadequate vaporization resulting in possible LNG carry over to EW9000 leading to lower temperature of gas to compressor with possible damage (economical losses)	...activate closure of HV-939			
		160.2. Malfunction of PIC-1900A opening HV-1912 when is not required	160.2.1. BOG routed to cold flare with minor environmental concern	160.2.1.1. HV-1912 reported to PLC screen			
			160.2.2. BOG routed to cold flare resulting in loss of suction flowrate/pressure to compressor (see loss of compressor suction feed in no/less flow in this node)				
		160.3. Unexpected opening of HV-915	160.3.1. BOG gas routed to cold flare instead of to compressor suction leading to minor environmental concern	160.3.1.1. Valve is FC and has discrepancy alarm on HVs			
			160.3.2. BOG routed to cold flare resulting in loss of suction flowrate/pressure to compressor (see loss of compressor suction feed in no/less flow in this node)	160.3.2.1. Valve is FC and has discrepancy alarm on HVs			
		160.4. Unexpected opening of HV-917	160.4.1. BOG partially routed to thermal oxidizer with potential operational upsets for thermal oxidizer	160.4.1.1. Valve is FC and has discrepancy alarm on HVs			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Flow
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	160. Misdirect Flow (cont.)	160.5. Malfunction PIC-900/PIC-904 opening PV-905 when not required	160.5.1. Compressor put in recycle mode resulting in impact on upstream system (see compressor failure) and loss recovery BOG to NG feed				
			160.5.2. Possible pressure build up on compressor suction system (DP=6 barg) and possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel	160.5.2.1. PAHH-911 activate trip of compressor			
		160.6. Unexpected opening of HV-905	160.6.1. BOG gas routed to cold flare instead of to NG feed suction leading to minor environmental concern	160.6.1.1. Discrepancy alarm on HVs			
			160.6.2. BOG routed to cold flare resulting in loss of BOG recovery stream (less than 5% of feed)	160.6.2.1. Discrepancy alarm on HVs			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Temperature
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	161. Lower Temperature	161.1. Refer to More and Misdirect Flow in this node					
		161.2. Loss of duty in EW9000 (loss of LP steam supply including malfunction of TIC-952)	161.2.1. Lower temperature on downstream EW9000 coil and consequent lower temperature on downstream piping with possible embrittlement of piping leading to mechanical damage and loss of containment with possible fire/explosion hazard	161.2.1.1. TALL-913 activate closure of HV-939 (same action initiated by TALL-952)			
More	162. Higher Temperature	162.1. TIC-952 malfunction increasing heat input to EW9000	162.1.1. Higher temperature (up to 100°C) of BOG gas to compressor resulting in possible overheating of EW9000 process gas coils (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		:See 47		
		162.2. Loss of cooling water to HW9101	162.2.1. Higher temperature of natural gas to second stage of compressor resulting in potential damage to internals and consequent economical losses	162.2.1.1. TAHH-902 activate trip of compressor			
		162.3. Loss of cooling water to HW9102	162.3.1. Higher temperature of natural gas to third stage of compressor resulting in potential damage to internals and consequent economical losses	162.3.1.1. TAHH-903 activate trip of compressor			
		162.4. Loss of cooling water to...	162.4.1. Higher temperature of...		42. Add a high high...	SIAD...	

Worksheet

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Temperature
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	162. Higher Temperature (cont.)	...HW9103	...BOG recovery gas (estimated approximately 175°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire 162.4.2. No impact on natural gas feed due to increased temperature of BOG recovery gas stream due to limited flowrate from compressor (less than 5% of feed)		...temperature interlock downstream HW9103 to activate trip of BOG compressor C9100	...MI	

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Pressure
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	163. Lower Pressure	163.1. Refer to No/Less and Misdirect flow in this node					
More	164. Higher Pressure	164.1. Refer to No/Less and Misdirect flow in this node					
		164.2. External fire/Thermal...	164.2.1. Overpressurization of...	164.2.1.1. All isolatable...	:See 7		

Worksheet

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Pressure
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	164. Higher Pressure (cont.)	...expansion	...involved equipment/piping with possible mechanical damage	...equipment and piping on LNG sections are protected by pressure relief devices sized for this case	43. Provide additional pressure relief device against External fire/Thermal expansion on LNG build up line between last block valve and new HV	SIAD MI	

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Level
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	165. No/less Level	165.1. Not applicable					
More	166. Higher Level	166.1. Not applicable					

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Composition
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	167. Different Composition	167.1. By-pass of BOG compressor post-filter F9101 left open after maintenance	167.1.1. Possible carry over of piston ring wear material to NG feed with negligible impact				

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Intention: EW9000: OTin = -166,53 °C, OTout = 20 °C
C9100: OPsuction = 1,2 barg; OPdischarge = 44,5 barg
VT19001: OT = -166,53 °C
P19001: OPsuction = 1,5 barg; OPdischarge = 6,5 barg
Notes:
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Services / Utilities
Equipment: VT19001, E19000, EW9000, C9100

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	168. No Services / Utilities	168.1. No additional cause identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	169. No/less Flow	169.1. Unexpected closure of HV-1902A during truck loading mode	169.1.1. No impact on LNG tank				
			169.1.2. Loss of suction feed to P19000 with possible pump damage due to dry running (economical losses with no safety impact since pump is submerged pump without seals)	169.1.2.1. PDALL-1938A activate trip of pump P19000			
			169.1.3. Interruption of truck loading operation with operational upset (loss of 50% capacity to be sent to truck)	169.1.3.1. Discrepancy alarm on HVs 169.1.3.2. Intervention of pump protection will freeze the loading sequence providing an alarm at loading area. On control room board operator will receive alarm associated to intervention of PDALL-1938A			
		169.2. Failure of pump P19000 when required in operation	169.2.1. No impact on LNG tank				
			169.2.2. Interruption of truck loading operation with operational upset (loss of 50% capacity to be sent to truck)	169.2.2.1. Discrepancy alarm on pump status 169.2.2.2. Pump faulty status will freeze the loading sequence providing an alarm at loading area.			
		169.3. Malfunction of FIC-1950A acting on P19000 pump VFD resulting in reduced pump motor speed	169.3.1. Increased duration in truck loading operation and consequent operational upset (loss of 50% capacity to be sent...				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	169. No/less Flow (cont.)	169.3. Malfunction of FIC-1950A acting on P19000 pump VFD resulting in reduced pump motor speed (cont.)	...to truck)				
		169.4. Unexpected closure of HV-1951A, FV-1950A, HV-1952A	169.4.1. Pressure build up on pump discharge line up to shut-off pressure of pump P19000 (estimated <15 barg) with no impact on mechanical integrity of piping according to design criteria				
			169.4.2. Overheating of LNG trapped in the pump (no safety impact since pump is submerged pump without seals)	169.4.2.1. PDIC-1939A to open PDV-1939A to recycle LNG back to tank 169.4.2.2. PDAHH-1938A activate trip of pump P19000			
			169.4.3. Interruption of truck loading operation with operational upset (loss of 50% capacity to be sent to truck)	169.4.3.1. Discrepancy alarm on HVs (not effective for FV-1950A) 169.4.3.2. Intervention of pump protection will freeze the loading sequence providing an alarm at loading area. On control room board operator will receive alarm associated to intervention of PDALL-1938A			
			169.4.4. Potential pressure surge resulting in mechanical damage...		44. Surge study to be provided for LNG truck...	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	169. No/less Flow (cont.)	169.4. Unexpected closure of HV-1951A, FV-1950A, HV-1952A (cont.)	...to LNG transfer line from pump to last on/off valve resulting in potential LNG leak and possible fire/explosion hazard		...loading lines (including worst case scenario: closure of on/off valve on road tanker side)		
		169.5. Blocked inlet of LNG connection on road tanker	169.5.1. Pressure build up on pump discharge line up to shut-off pressure of pump P19000 (estimated <15 barg) with no impact on mechanical integrity of piping according to design criteria. No impact on flexible hoses according to design criteria (PN40)				
			169.5.2. Overheating of LNG trapped in the pump (no safety impact since pump is submerged pump without seals)	169.5.2.1. PDIC-1939A to open PDV-1939A to recycle LNG back to tank 169.5.2.2. PDAHH-1938A activate trip of pump P19000			
			169.5.3. Interruption of truck loading operation with operational upset (loss of 50% capacity to be sent to truck)	169.5.3.1. Discrepancy alarm on HVs (not effective for FV-1950A) 169.5.3.2. Intervention of pump protection will freeze the loading sequence providing an alarm at loading area. On control room board operator will receive alarm associated to intervention of PDALL-1938A			

Worksheet

Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	169. No/less Flow (cont.)	169.6. Unexpected closure of HV-1957A, PV-1958A, HV-1956A (when BOG is routed back to tank) or unexpected closure of PV-1959A, HV-1958A, FV-914 (when BOG from road tanker is routed to BOG compressor)	169.6.1. Pressure build up in road tanker up to shut-off pressure of pump P19000 (estimated <15 barg) and potential overpressurization leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	169.6.1.1. PAHH-1960A to activate trip of pump P19000 and to close on/off pneumatic valve on truck inlet by means of SY-1950AA (same actions initiated also by PAHH-1961A, not effective only in case of blocked outlet on gas return line inside road tanker)	45. Set point of PAHH-1960A and PAHH-1961A shall be defined taking into account lowest design pressure for road tankers (design pressure of road tankers to be checked by OGE, currently available value is 7 barg)	OGE	
			169.6.2. No impact on LNG tank				
More	170. More Flow	170.1. Malfunction of FIC-1950A opening more than required FV-1950A at the beginning of loading operation	170.1.1. In case road tanker is warm, possible increased of generation of BOG resulting in pressure build up in road tanker and potential overpressurization leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	170.1.1.1. PAHH-1960A to activate trip of pump P19000 and to close on/off pneumatic valve on truck inlet by means of SY-1950AA (same actions initiated also by PAHH-1961A)			
		170.2. Malfunction of FIC-1950A opening FV-1950A more than required and increasing pump motor speed through VFD	170.2.1. No significant consequences identified				
	171. More Flow (LNG loaded Amount)	171.1. Malfunction of WQ-1900A leading to higher amount of LNG loaded on road tanker	171.1.1. Possible overfilling of road tanker with consequent overpressurization of road tanker leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	171.1.1.1. FQI-1950A to provide alarm in case of discrepancy higher than 5% with WI-1900A (if loaded amount is above 80% of tanker capacity sequence is stopped)			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	171. More Flow (LNG loaded Amount) (cont.)	171.1. Malfunction of WQ-1900A leading to higher amount of LNG loaded on road tanker (cont.)	171.1.1. Possible overfilling of road tanker with consequent overpressurization of road tanker leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel (cont.)	171.1.1.2. PAHH-1960A to activate trip of pump P19000 and to close on/off pneumatic valve on truck inlet by means of SY-1950AA (same actions initiated also by PAHH-1961A)			
			171.1.2. Possible overfilling of road tanker with consequent liquid carry over to BOG line back to heater EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment	171.1.2.1. FQI-1950A to provide alarm in case of discrepancy higher than 5% with WI-1900A (if loaded amount is above 80% of tanker capacity sequence is stopped)			
				171.1.2.2. TALL-914 activate closure HV-1958A/B			
Reverse	172. Reverse Flow	172.1. Failure of pump P19000 when required in operation	172.1.1. Possible back flow from road tanker to tank with no impact				
Misdirect	173. Misdirect Flow	173.1. HV-1932A stuck in open position	173.1.1. No impact expected	173.1.1.1. Discrepancy alarm on HVs			
		173.2. Malfunction of PDIC-1939A opening PDV-1939A when not required	173.2.1. Reduced pressure and flowrate on P19000 discharge resulting in delayed operation and consequent operational upset. Potential damage to pump motor due to overload (possible economical losses)	173.2.1.1. Internal protection provided against pump motor overload			
				173.2.1.2. PDALL-1938A activate trip of pump P19000			
		173.3. HV-1950A stuck in...	173.3.1. LNG partially routed...				

Worksheet

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow

Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	173. Misdirect Flow (cont.)	...open position after cooling (if required)	...back to tank through BOG line with no impact on storage tank				
			173.3.2. Reduced flowrate to road tanker resulting in delayed operation and consequent operational upset. Potential damage to pump motor due to overload (possible economical losses)	173.3.2.1. Discrepancy alarm on HVs 173.3.2.2. Internal protection provided against pump motor overload 173.3.2.3. PDALL-1938A activate trip of pump P19000			
		173.4. HV-1953A stuck in open position after hose drain	173.4.1. During next loading operation, LNG partially routed to BOG line with consequent liquid carry over to heater EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment	173.4.1.1. Permissive to not start loading sequence if HV-1953A is detected in inconsistent position 173.4.1.2. TALL-914 activate closure HV-1958A/B			
		173.5. HV-1954A / HV-1955A stuck in open position after end of purging operation	173.5.1. Nitrogen at 9 barg enters into LNG loading / BOG lines and consequent pressure build up with no impact on mechanical integrity (DP=15 barg)				
			173.5.2. After the end of pressure test, in case of increased pressure on LNG loading / BOG lines, sequence will be stopped by PAHH-1960A / PAHH-1961A leading to delay in operation		46. Provide a PSV on nitrogen purging line to LNG / BOG lines (set at adequate value)	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	173. Misdirect Flow (cont.)	173.6. Unexpected opening of HV-1959A	173.6.1. BOG routed to cold flare and possible minor environmental concern	173.6.1.1. Discrepancy alarm on HVs			
		173.7. Malfunction of PIC-1959AB opening PV-1959 when not required	173.7.1. BOG routed to BOG compressor instead that directly to tank with minor operational upset				
		173.8. Unexpected opening of HV-1963A	173.8.1. Nitrogen entrainment on BOG stream routed to compressor suction side with increased content of nitrogen in process flow (minor operational upset)	173.8.1.1. Discrepancy alarm on HVs			
			173.8.2. Nitrogen entrainment on BOG stream with pressure build up on C9100 suction resulting in possible mechanical damage and economical losses	173.8.2.1. HV-1963A is FC and managed by depressurization/purging sequence 173.8.2.2. Discrepancy alarm on HVs 173.8.2.3. PAH-900 173.8.2.4. PAHH-910 activate trip of compressor C9100			
			173.8.3. After compressor shut down pressure build up (OP of nitrogen =9barg) on blocked in suction system (DP=10 barg) with no impact on mechanical integrity				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Temperature   Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	174. Lower Temperature	174.1. No causes identified for tank VT19000, pump P19000 and truck loading bay TL19000					
		174.2. See overfilling scenario for road tanker (More flow)					
		174.3. Loss of LP steam in EW9000 including malfunction of TIC-952 closing TV-952	174.3.1. BOG routed to BOG compressor inlet line at -168°C instead of 20°C with possible embrittlement of piping resulting in mechanical and injuries to personnel (fire/explosion hazard)	174.3.1.1. TALL-914 activate closure HV-1958A/B			
			174.3.2. Freezing in EW9000 is not expected due to limited flowrate of BOG and continuous circulation of water through EW9000				
More	175. Higher Temperature	175.1. No causes identified for tank VT19000					
		175.2. Loss of pump cool down (HV-1932A not open on demand including TSL-1932A malfunction)	175.2.1. Loss of pump cooling down with possible pump damage due to cavitation (economical losses with no safety impact since pump is submerged pump without seals)	175.2.1.1. PDALL-1938A activate trip of pump P19000			
		175.3. See more flow to road tanker during loading operation					
		175.4. Inadequate cooling of LNG line (HV-1950 not opening on demand including TSL-...	175.4.1. At the beginning of road tanker loading, possible increased of generation of BOG...	175.4.1.1. PAHH-1960A activate trip of pump P19000 and to close...			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Temperature
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	175. Higher Temperature (cont.)	...1951 malfunction)	...resulting in pressure build up in road tanker and potential overpressurization leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	...on/off pneumatic valve on truck inlet by means of SY-1950AA (same actions initiated also by PAHH-1961A)			
		175.5. TIC-952 malfunction increasing heat input to EW9000	175.5.1. Higher temperature (up to 100°C) of BOG gas to compressor resulting in possible overheating of EW9000 process gas coils (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		47. Review design temperature of EW9000 coils up to 100°C	SIAD MI	

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Pressure
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	176. Lower Pressure	176.1. Malfunction of PIC-1910A to not open PV-1910A on demand	176.1.1. Pressure decrease in VT-19000, no impact expected on VT19000 operation according to NPSH requirement				
		176.2. See Misdirect and No/Less flow in this node					
		176.3. PIC-1959AB malfunction fully opening PV-1959A	176.3.1. No impact on loading operation				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Pressure Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	176. Lower Pressure (cont.)	176.3. PIC-1959AB malfunction fully opening PV-1959A (cont.)	176.3.2. Transient increase overall BOG flowrate to compressor suction side managed by FV-914				
More	177. Higher Pressure	177.1. See flow parameter and high temperature					
		177.2. Malfunction PIC-1910 to improperly manage BOG system or any other upset on BOG loop (including compressor C9100 failure)	177.2.1. Pressure build up in VT19000 leading to potential overpressurization (DP=5 barg) leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	177.2.1.1. PAH1900A and operator response / to open HV1912 to cold flare 177.2.1.2. PSV 1AB/ 1AA or PSV 2AA/ 2AB (2x100%)			
		177.3. Loss of vacuum on V19000 jacket	177.3.1. Loss of insulation capacity and consequent operational upset	177.3.1.1. Event detectable by ice formation on VT19000			
		177.4. Undetected leakage on VT19000	177.4.1. LNG entrainment on V19000 jacket resulting in potential overpressurization and mechanical damage	177.4.1.1. Rupture disk DS1A sized according to design code for cryogenic tank EN13458			
		177.5. External fire/Thermal expansion	177.5.1. Overpressurization of involved equipment/piping with possible mechanical damage	177.5.1.1. All isolatable equipment and piping on LNG sections are protected by pressure relief devices sized for this case	:See 7		

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Level Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	178. No/less Level	178.1. Inadequate monitoring of tank level including LI-1900A or LI-1901A malfunction	178.1.1. Loss of level in VT19000 and consequent possible pump damage due to dry running (economical losses with no safety impact since pump is submerged pump without seals)	178.1.1.1. LALL-1900A or LALL1901A to trip pump P19000 (at least one is available since level transmitter are fully independent) 178.1.1.2. PDALL-1938A activate trip of pump P19000			
More	179. Higher Level	179.1. Inadequate monitoring of tank level including LI-1900A or LI-1901A malfunction	179.1.1. Level build up in VT19000 and consequent overfilling leading to blocked outlet condition for LNG separator bottom line resulting in level build up in S7003 (see no/less flow in node #11)	179.1.1.1. LAHH-1900A or LAHH1901A activate closure of HV-1913A (after closure of HV-1913A all LNG production will be diverted to VT19001) 179.1.1.2. See dedicated safeguard against overfilling provided for S7003 (node #11) in case second tank is not available to accommodate overall LNG			

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Composition Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	180. Different Composition	180.1. No causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Services / Utilities
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	181. No Services / Utilities	181.1. No additional cause identified					

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Intention: P19000: OPsuction = 1,5 barg, OPdischarge = 6,5 barg
EW9000: OTin = -166,53 °C, OTout = 20 °C
Notes: During normal operation both tanks are in filling mode and simultaneous truck loading mode
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Other
Equipment: VT19000, P19000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	182. Other Than Other	182.1. Hose failure	182.1.1. Release of LNG on loading area with possible fire/explosion hazard	182.1.1.1. PALL-1960A activate trip of pump P19000, close HV-1952A and SY-1950AA	48. Shut down of LNG loading shall be also activated by LNG high flow gradient according to requirement of TRGS 751 4.1.6 paragraph 6 codes	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Flow
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	183. No/less Flow	183.1. Loss of gas stream from analyzers fast loop to V16200 or loss of stream from EW9000 (not condensable gas from LNG separator) to V16200	183.1.1. No impact on this node				
		183.2. Unexpected closure of HV-1646	183.2.1. Blocked outlet for stripping condensate separator S2011 (see no/less flow in node #6 due to PV-275 unexpected closure)				
			183.2.2. No impact on this node				
		183.3. No HC flow from S1003 (any cause relative to node #03)	183.3.1. No impact on this node				
		183.4. Unexpected closure of HV-1645	183.4.1. Pressure build up in V16200 leading to increase back pressure for incoming streams (see blocked outlet scenario for node #11 and #06)		49. PAHH-1640 shall also close HV-1646 to segregate stripper condensate separator S2011 from heavy HC KO drum V16200	SIAD MI	
			183.4.2. Pressure build up in V16200 leading to increase back pressure for analyzers fast loop. No impact on mechanical integrity according to design criteria				
			183.4.3. Pressure build up in V16200 due to vaporization of liquid and possible overpressurization resulting in possible mechanical damage leading to injuries to personnel/leakages and fire hazard		50. PSV-914 shall be verified for blocked outlet condition on V16200 51. PAHH-1640 shall also close HV-721 and trip H16200/H16201	SIAD MI SIAD MI	

Worksheet

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Flow
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	183. No/less Flow (cont.)	183.4. Unexpected closure of HV-1645 (cont.)	183.4.4. No impact on thermal oxidizer				
More	184. More Flow	184.1. Gas breakthrough from S1003 (see Low level in node #03)	184.1.1. See node #03 for impact on V16200 mechanical integrity				
			184.1.2. Pressure build up in V16200 leading to potential increase back pressure for incoming streams (see blocked outlet scenario for node #11 and #06)		:See 49		
Reverse	185. Reverse Flow	185.1. Refer to no/less flow and more flow in this node					
		185.2. No causes identified for backflow from thermal oxidizer IN16200					
Misdirect	186. Misdirect Flow	186.1. No causes identified					

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Temperature
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	187. Lower Temperature	187.1. No causes identified for low temperature on incoming streams	:				Even in case of upset in EW9000 significant temperature decrease in not expected taking into account limited flowrate compared to CO2 incoming...

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Temperature
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	187. Lower Temperature (cont.)	187.1. No causes identified for low temperature on incoming streams (cont.)	: (cont.)				...flowrate at approximately 100°C
		187.2. See more level in this node (Failure on demand of H16200)					
		187.3. Failure on demand of H16201 including TDY-1644 malfunction to switch off H16201 or to not switch on on demand	187.3.1. Lower temperature of stream routed to thermal oxidizer inlet resulting in possible condensation and droplets carry over to thermal oxidizer leading to operational upset / possible damage		52. Investigate impact of liquid carry over to thermal oxidizer in case of unavailability of superheater H16201 or in case of loss of heater H16200	SIAD MI	
More	188. Higher Temperature	188.1. Higher temperature of gas stream from EW9000 (<100°C) (see node #11)	188.1.1. No impact on this node				
		188.2. Higher temperature of CO2 vent stream S2011/H2001 (see node #06)	188.2.1. No impact on this node				
		188.3. No causes identified for higher temperature from flash vessel S1003					
		188.4. Malfunction of LI-1641 to switch on H16200 when not required or to not stop on demand	188.4.1. Loss of level in V16200 leading to dry running of H16200 with consequent potential overheating of electrical bundles and damage (economical losses)	188.4.1.1. LALL-1640 activate trip of H16200 (same action is initiated by TAHH-1640)			
		188.5. Malfunction of TDY-1644 to not switch off H16201 on demand or to switch on when not required	188.5.1. Higher temperature of gas routed to thermal oxidizer and potential for damage to internals (economical losses)		53. Relocate TI-1644 downstream H16201 and add a high high temperature interlock to...	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Temperature
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	188. Higher Temperature (cont.)	188.5. Malfunction of TDY-1644 to not switch off H16201 on demand or to switch on when not required (cont.)	188.5.1. Higher temperature of gas routed to thermal oxidizer and potential for damage to internals (economical losses) (cont.)		...trip H16201		
			188.5.2. Higher temperature of gas on V16200 overhead line. According to limited duty of H16201 temperature build up is estimated in approximately 10 °C with no impact on mechanical integrity of piping		:See 53		
			188.5.3. Possible overheating of H16201 electrical bundle leading to mechanical damage and economical losses	188.5.3.1. TAHH-1641 activate trip of H16201			

Session: (8) 05/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Pressure
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	189. Lower Pressure	189.1. No causes identified					
More	190. Higher Pressure	190.1. Refer to no/less and more flow in this node					
		190.2. External fire	190.2.1. Overpressurization of involved equipment	190.2.1.1. PSV-914 to protect V16200 including fire scenario			

Worksheet

Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Level
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	191. No/less Level	191.1. See higher temperature in this node					
More	192. Higher Level	192.1. Failure on demand of H16200 including malfunction of LI-1641	192.1.1. Liquid accumulation on V16200 resulting in possible overfilling and liquid carry over to thermal oxidizer leading to operational upset/possible damage	192.1.1.1. LAHH-1640 activate trip of thermal oxidizer and close HV-1645	:See 52 54. LAHH-1640 shall also close HV-1646 to prevent potential liquid backflow to S2011 and trip H16201 to prevent thermal expansion of trapped material	 SIAD MI	

Session: (8) 05/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Composition
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	193. Different Composition	193.1. No causes identified					

Session: (8) 05/04/2023
Node: (14) Heavy HCs KO drum
Intention:
Notes:
Drawings: I20784 Sh 70
Parameter: Other
Equipment: V16200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	194. Other Than Other	194.1. Corrosion due to presence of CO2 is not expected according to operating condition (low partial pressure) and material selection (stainless steel)					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Flow
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	195. No/less Flow	195.1. No cause identified (during normal operation)					
	196. No/less Flow (nitrogen flushing)	196.1. Refer To node #32					
More	197. More Flow	197.1. Relief scenario - worst case (PV-703 wide opening leading to intervention of PV-705 or HV-715)	197.1.1. No impact since cold flare and cold flare header are sized according to worst relief scenario				
Reverse	198. Reverse Flow	198.1. Refer To node #32 for potential air entrainment in case of loss of flushing nitrogen					
Misdirect	199. Misdirect Flow	199.1. Unexpected intervention of snuffing gas system	199.1.1. Emptying of snuffing gas cylinders leading to unavailability on demand	199.1.1.1. Weight scale provided including alarm to detect emptying of cylinders (minimum requirement to vendor)			
		199.2. Cold flare drain valve left open after maintenance or valve passing	199.2.1. Continuous leakage of nitrogen during normal operation. Potential hydrocarbon leak with fire hazard in case of relief on cold flare header		55. Provide additional positive isolation device on cold flare bottom drain line	SIAD MI	

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Temperature
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	200. Lower Temperature	200.1. Cold relief	200.1.1. No consequences since flare header material is compliant with cryogenic service				

Worksheet

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Temperature
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less (cont.)	200. Lower Temperature (cont.)	200.2. Low ambient temperature	200.2.1. In case of injection of snuffing gas (CO_2) potential condensation leading to potential mechanical damage of cold flare tip		56. Investigate if CO_2 is suitable for snuffing purpose on cold flare, taking into account minimum ambient temperature and possibility of condensation	SIAD MI	
More	201. Higher Temperature	201.1. Hot relief due to fire scenario	201.1.1. No impact on mechanical integrity of flare header according to relevant design temperature (260°C) defined taking into account worst case for relief scenario in case of external fire				
		201.2. Ignition of gas at cold flare tip during relief scenario	201.2.1. Potential mechanical damage of cold flare tip leading to operation disruption (plant shut down for unplanned maintenance)	201.2.1.1. TAHH-1600 activate snuffing system by opening solenoid valves provided on each cylinder (3 cylinder in operation and 3 in stand-by)			No injuries to personnel expected since flare elevation has been defined to not exceed 3 kW/m2 at 1.5 m above ground level, at 1 m from flare stack

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Pressure
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	202. Lower Pressure	202.1. See no/less and misdirect flow					
		202.2. See no/less flow of nitrogen (node #32)					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Pressure
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	203. Higher Pressure	203.1. Relief scenario - worst case (PV-703 wide opening leading to intervention of PV-705 or HV-715)	203.1.1. Increase back pressure on cold flare header up to 1 barg with no impact on functionality of pressure relief devices since they're designed taking into account maximum back pressure on cold flare header				

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Level
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	204. No/less Level	204.1. No causes identified					
More	205. Higher Level	205.1. Refer to misdirect flow in node #11 (opening of HV-711) for massive incoming liquid flowrate from LNG separator S7003					

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Intention:
Notes:
Drawings: I20784 Sh 39A
Parameter: Composition
Equipment: V16000, FL16000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	206. Different Composition	206.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (20) Cooling water circuit
Intention: OT to process = 40 °C , OT return = 50 °C
Notes:
Drawings: I20784 Sh 50; I20784 Sh 51; I20784 Sh 65; I20784 Sh 66; I20784 Sh 67; I20784 Sh 68
Parameter: Composition
Equipment: E8000, E8001, P8000A/B, V8000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	207. Different Composition	207.1. Injection of biocide agent	:		57. Properties of biocide agent and potential associated hazards to be investigated	SIAD MI	

Session: (8) 05/04/2023
Node: (20) Cooling water circuit
Intention: OT to process = 40 °C , OT return = 50 °C
Notes:
Drawings: I20784 Sh 50; I20784 Sh 51; I20784 Sh 65; I20784 Sh 66; I20784 Sh 67; I20784 Sh 68
Parameter: Services / Utilities
Equipment: E8000, E8001, P8000A/B, V8000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	208. No Services / Utilities	208.1. Loss of electrical power	208.1.1. Unavailability of cooling water and loss of circulation leading to potential freezing	208.1.1.1. Cooling water pumps P8000A/B are supplied by EDG (automatically started in case of black out)			

Session: (8) 05/04/2023
Node: (20) Cooling water circuit
Intention: OT to process = 40 °C , OT return = 50 °C
Notes:
Drawings: I20784 Sh 50; I20784 Sh 51; I20784 Sh 65; I20784 Sh 66; I20784 Sh 67; I20784 Sh 68
Parameter: Other
Equipment: E8000, E8001, P8000A/B, V8000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	209. Other Than Other	209.1. Removal of vibration protection from air cooler fans	209.1.1. No impact expected under safety prospective since area underneath air coolers is not accessible (damage to personnel in case of fan mechanical failure is not possible)				
		209.2. Unavailability of cooling water circuit (loss of circulation or higher temperature due to air cooler failure)	209.2.1. See nodes relevant to cooling water users for impact on process in case of unavailability of cooling water				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (21) Steam generation
Intention:
Notes:
Drawings: I20784 Sh 10; I20784 Sh 15; I20784 Sh 37; I20784 Sh 38; I20784 Sh 50
Parameter: Other
Equipment: V15100, P15100A/B, SG15200

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	210. Other Than Other	210.1. Unavailability of steam circuit (loss of circulation)	210.1.1. See nodes relevant to steam users for impact on process in case of unavailability of steam				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH

Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (22) Condensate collection
Intention:
Notes:
Drawings: I20784 Sh 10; I20784 Sh 16; I20784 Sh 37; I20784 Sh 38; I20784 Sh 50
Parameter: Level
Equipment: HW15000, P15000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	211. Higher Level	211.1. Unavailability of condensate pump P15000	211.1.1. Level build up in condensate collection drum, leading to potential overfilling and release of hot condensate (85°C) from vent leading to possible injuries to personnel		58. Ensure condensate collection drum vent to be routed to safe location	SIAD MI	

Worksheet

Session: (8) 05/04/2023
Node: (23) Chilled water circuit
Intention: P11000A/B: OPsuction = 2 barg, OPdischarge = 4 barg
Notes:
Drawings: I20784 Sh 15; I20784 Sh 25; I20784 Sh 36; I20784 Sh 51
Parameter: Temperature
Equipment: P11000A/B, V11000, FRU11000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	212. Lower Temperature	212.1. Chilled water pump P11000A/B shut down	212.1.1. Possible freezing on piping downstream chilled package due to thermal inertia of chiller	212.1.1.1. Adequate glycol content to prevent freezing of chilled water			

Session: (8) 05/04/2023
Node: (23) Chilled water circuit
Intention: P11000A/B: OPsuction = 2 barg, OPdischarge = 4 barg
Notes:
Drawings: I20784 Sh 15; I20784 Sh 25; I20784 Sh 36; I20784 Sh 51
Parameter: Services / Utilities
Equipment: P11000A/B, V11000, FRU11000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	213. No Services / Utilities	213.1. Loss of electrical power	213.1.1. Unavailability of chilled water and loss of circulation leading to potential freezing	213.1.1.1. Chilled water pumps P11000A/B are supplied by EDG (automatically started in case of black out)			

Session: (8) 05/04/2023
Node: (23) Chilled water circuit
Intention: P11000A/B: OPsuction = 2 barg, OPdischarge = 4 barg
Notes:
Drawings: I20784 Sh 15; I20784 Sh 25; I20784 Sh 36; I20784 Sh 51
Parameter: Other
Equipment: P11000A/B, V11000, FRU11000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	214. Other Than Other	214.1. Unavailability of chilled water circuit (loss of circulation or higher temperature due to chiller failure)	214.1.1. See nodes relevant to chilled water users for impact on process in case of unavailability of chilled water				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (24) Demi water package
Intention:
Notes:
Drawings: I20784 Sh 68
Parameter: Composition
Equipment:

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	215. High Concentration	215.1. Higher salt (conductivity) on reverse osmosis drain	215.1.1. Possible off spec stream to downstream treatment unit		59. Investigate potential impact of waste water from demi water package routed to waste water collection/treatment system	OGE (TPLT)	

Session: (8) 05/04/2023
Node: (24) Demi water package
Intention:
Notes:
Drawings: I20784 Sh 68
Parameter: Other
Equipment:

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	216. Other Than Other	216.1. Handling of chemicals harmful for eye and skin	216.1.1. Possible injuries to personnel in case of leakage		60. Investigate requirement for emergency showers/eye showers on demi water package due to presence of harmful chemicals	OGE (TZSA)	

Worksheet

Session: (8) 05/04/2023
Node: (25) Instrument air production
Intention:
Notes:
Drawings: I20784 Sh 42; I20784 Sh 43; I20784 Sh 60
Parameter: Pressure
Equipment: F7701, V7701, V7703, V7702

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	217. Lower Pressure	217.1. Upset on instrument air package	217.1.1. Loss of instrument air to users resulting in taking of fail safe position for each pneumatic valve leading to unexpected plant shut-down	217.1.1.1. Nitrogen back up activated by any malfunction on the package (to open HV-1601 (FO) and consequent nitrogen injection through PCV-1612)			
More	218. Higher Pressure	218.1. Malfunction of PCV-770 (fully open)	218.1.1. IA supplied to header at 12 barg instead of 7 barg. No impact on mechanical integrity of piping according to relevant schedule (DP = 16 barg)				
			218.1.2. IA supplied to pneumatic valves at 12 barg instead of 7 barg with consequent possible damage of valve actuator and economical losses	218.1.2.1. PSV-771			
		218.2. Malfunction of dedicated inlet filter reducer on single pneumatic valve	218.2.1. Possible damage of actuator on involved pneumatic valve with economical losses / impact on operation	218.2.1.1. Pneumatic valves provided with inlet filter reducer are protected by dedicated PSVs to prevent damage in case of inlet filter reducer failure			

Session: (8) 05/04/2023
Node: (25) Instrument air production
Intention:
Notes:
Drawings: I20784 Sh 42; I20784 Sh 43; I20784 Sh 60
Parameter: Composition
Equipment: F7701, V7701, V7703, V7702

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	219. Different Composition	219.1. Upset in instrument air package leading to inadequate drying of air	219.1.1. Possible presence of humidity on IA supply to pneumatic valve leading to accumulation on valve pressure...	219.1.1.1. Dew point analyzer provided on AI package as minimum requirement for vendor			

Session: (8) 05/04/2023
Node: (25) Instrument air production
Intention:
Notes:
Drawings: I20784 Sh 42; I20784 Sh 43; I20784 Sh 60
Parameter: Composition
Equipment: F7701, V7701, V7703, V7702

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different (cont.)	219. Different Composition (cont.)	219.1. Upset in instrument air package leading to inadequate drying of air (cont.)	...reducer drainage pot and potential for damage in case of freezing due to ambient temperature	219.1.1.1. Dew point analyzer provided on AI package as minimum requirement for vendor (cont.)			

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	220. No/less Flow	220.1. Malfunction of PIC-740A closing PV-740A on nitrogen make up stream or any other cause for loss of nitrogen make-up or unexpected closure of HV-714, HV-706	220.1.1. Inadequate compensation of nitrogen losses through compressor and turbine seals with loss of efficiency of nitrogen compressor overtime and upset in liquefaction (nitrogen make up is approximately 0,3% of nitrogen circulation to compressor)	220.1.1.1. Independent pressure monitoring at compressor suction			
			220.1.2. In case of unexpected closure of HV-714, HV-706, loss of nitrogen purging to cold box resulting in potential humidity entrainment and consequent freezing and potential ice formation on perlite pellet leading to decrease in efficiency of primary exchanger overtime	220.1.2.1. Nitrogen back-up through PCV-737 220.1.2.2. Routine inspection on PDI-735 and PDI-739			
		220.2. Unexpected closure of PCV-736	220.2.1. In case of unexpected closure of HV-714, HV-706, loss of nitrogen purging to cold box resulting in potential humidity entrainment and consequent freezing and potential ice formation on perlite pellet...	220.2.1.1. Routine inspection on PDI-735 and PDI-739			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	220. No/less Flow (cont.)	220.2. Unexpected closure of PCV-736 (cont.)	...leading to decrease in efficiency of primary exchanger overtime	220.2.1.1. Routine inspection on PDI-735 and PDI-739 (cont.)			
		220.3. Potential plugging of temporary strainer on compressor C7400 suction	220.3.1. No impact during normal operation since this strainer will be removed after start-up phase				
		220.4. Compressor failure/stop (any cause)	220.4.1. Loss of circulation for cooling medium resulting in loss of LNG production (see higher temperature in node #11)				
			220.4.2. Lower suction pressure/flowrate for C7500/C7600 turbines boosters resulting in lower speed on turbines T7500/T7600 and potential for mechanical stress leading to reduction in equipment lifetime (economical losses)	220.4.2.1. PALL-750 activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760)			
			220.4.3. Lower suction pressure/flowrate for C7500/C7600 turbines boosters resulting in potential surge condition leading to turbines...	220.4.3.1. Anti surge control system opening UV-760 220.4.3.2. PALL-750...			

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	220. No/less Flow (cont.)	220.4. Compressor failure/stop (any cause) (cont.)	...boosters damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	...activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760) 220.4.3.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			
		220.5. Malfunction of compressor capacity control system leading to closure of compressor IGV	220.5.1. Possible reduced suction pressure/flowrate resulting in potential surge condition leading to compressor damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	220.5.1.1. Anti surge control system to open compressor by-pass valve (PCV) 220.5.1.2. USPM system to trip compressor in case of surge conditions 220.5.1.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			These safeguards are reported in detailed P&IDs of nitrogen compressor loop
			220.5.2. Reduction of circulation for cooling medium resulting in...				

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	220. No/less Flow (cont.)	220.5. Malfunction of compressor capacity control system leading to closure of compressor IGV (cont.)	...reduced efficiency of LNG production (see higher temperature in node #11)				
		220.6. Potential plugging of strainer on turbine boosters C7500/7600 suction	220.6.1. Slight reduction on turbine boosters C7500/7600 efficiency and consequent potential minor operational upset		61. Provide differential pressure measurements accross filters on turbine boosters C7500/7600 suctions by using existing instrumentation	SIAD MI	Additional temporary filter is provided for commissioning phase only. This temporary filter will be removed for normal operation as per SIAD commissioning procedure
		220.7. Unexpected closure of UV-761	220.7.1. Lower speed on turbines T7500/T7600 and potential for mechanical stress leading to reduction in equipment lifetime (economical losses)	220.7.1.1. Low low speed interlock protection SALL 9B on cold turbine and SALL 9A on warm turbine to close HV-712/HV-710			
			220.7.2. Loss of circulation for cooling medium resulting in loss of LNG production (see higher temperature in node #11)				

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	220. No/less Flow (cont.)	220.7. Unexpected closure of UV-761 (cont.)	220.7.3. Blocked outlet condition for compressor resulting in potential surge condition leading to compressor damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	220.7.3.1. Anti surge control system to open compressor by-pass valve (PCV) 220.7.3.2. USPM system to trip compressor in case of surge conditions 220.7.3.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			
			220.7.4. Blocked outlet condition for boosters resulting in potential pressure build up on boosters discharge side leading to potential overpressurization (DP=31 barg), mechanical damage and potential injuries to personnel/nitrogen accumulation inside building with asphyxiation hazard	220.7.4.1. Anti surge control system opening UV-760 220.7.4.2. PSV-755 (warm booster outlet) and PSV-765 (cold booster outlet)			
		220.8. Potential plugging of strainer on turbine...	220.8.1. Slight reduction on turbine T7500/7600 efficiency...		62. Provide differential pressure measurements...	SIAD MI	Additional temporary filter is provided for...

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	220. No/less Flow (cont.)	...T7500/7600 suctions	...and consequent potential minor operational upset		...accross filters on turbines T7500/7600 suctions by using existing instrumentation		...commissioning phase only. This temporary filter will be removed for normal operation as per SIAD commissioning procedure
		220.9. Unexpected closure of HV-712 or HV-710 (quick closing valves)	220.9.1. Loss of circulation for cooling medium resulting in loss of LNG production (see higher temperature in node #11)				
			220.9.2. Blocked outlet condition for compressor resulting in potential surge condition leading to compressor damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	220.9.2.1. Anti surge control system to open compressor by-pass valve (PCV) 220.9.2.2. USPM system to trip compressor in case of surge conditions 220.9.2.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			Any iniziator that lead to turbine trip will also will also unload the compressor and open the by-pass valve UV-760 on boosters by-pass lines

Worksheet

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	221. More Flow	221.1. Malfunction of compressor capacity control system leading to opening of compressor IGV more than required	221.1.1. No significant consequences expected on process side and machine integrity				
			221.1.2. Possible overload of C7400 compressor motor resulting in damage with economical losses	221.1.2.1. Overload protection (high windings temperature) provided on compressor motor to trip the motor itself			
		221.2. Control room operator to increase opening of IGV on warm or cold turbine	221.2.1. Increased speed of turbine with potential overspeed and possible damage to turbine with economical losses	221.2.1.1. High high speed interlock protection SAHH 9B on cold turbine and SAHH 9A on warm turbine to close HV-712/HV-710			
			221.2.2. Increased speed of turbine with loss of efficiency in cooling capacity (see impact on node #11)				
Reverse	222. Reverse Flow	222.1. No causes identified					
		222.2. UV-761 doesn't close on demand (section shut down and depressurization)	222.2.1. Possible counter rotation of boosters and turbine. Damage is not expected since lubrication...				

Worksheet

Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Reverse (cont.)	222. Reverse Flow (cont.)	222.2. UV-761 doesn't close on demand (section shut down and depressurization) (cont.)	...is ensured by electrical driven lube oil pump (as per minimum requirement to vendor)				
Misdirect	223. Misdirect Flow	223.1. Malfunction of PIC-740B opening PV-740B when not required	223.1.1. Nitrogen partially routed to atmosphere (safe location) leading to lower suction pressure/flowrate for C7500/C7600 turbines boosters resulting in potential surge condition leading to turbines boosters damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	223.1.1.1. Anti surge control system opening UV-760 223.1.1.2. PALL-750 activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760) 223.1.1.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			
			223.1.2. Loss of nitrogen to atmosphere resulting in reduced circulation of cooling medium resulting in loss of LNG production (see higher temperature in node #11)				

Worksheet

Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	223. Misdirect Flow (cont.)	223.2. Malfunction of compressor antisurge control system opening PCV	223.2.1. Lower speed on turbines T7500/T7600 and potential for mechanical stress leading to reduction in equipment lifetime (economical losses)	223.2.1.1. Low low speed interlock protection SALL 9B on cold turbine and SALL 9A on warm turbine to close HV-712/HV-710			
			223.2.2. Loss of circulation for cooling medium resulting in loss of LNG production (see higher temperature in node #11)				
			223.2.3. Pressure build up on compressor suction side leading to potential overpressurization, mechanical damage and potential injuries to personnel/nitrogen accumulation inside building with asphyxiation hazard	223.2.3.1. PIC-740B to open PV-740B discharging to atmosphere (safe location) adequate for this scenario			
				223.2.3.2. Independent pressure monitoring at compressor suction with high high pressure interlock			
				223.2.3.3. PSV-741 sized including this scenario			
		223.3. Tube rupture in HW7400	223.3.1. Nitrogen at 27 barg enters into HW7400 and chilled ...	223.3.1.1. PSV-746 sized including this scenario			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	223. Misdirect Flow (cont.)	223.3. Tube rupture in HW7400 (cont.)	...water circuit (DP=8 barg) with potential mechanical damage and potential injuries to personnel	223.3.1.1. PSV-746 sized including this scenario (cont.)			
		223.4. Tube rupture in HW7601	223.4.1. Nitrogen at 70 barg enters into HW7601 and chilled water circuit (DP=8 barg) with potential mechanical damage and potential injuries to personnel	223.4.1.1. PSV-763 sized including this scenario			
		223.5. Unexpected opening of UV-760	223.5.1. Unloading condition for turbine booster resulting in loss of efficiency of cold turbine and reduction of cooling capacity (see impact on node #11)	223.5.1.1. Discrepancy alarm on UV			
			223.5.2. Pressure build up on compressor discharge side leading to potential overpressurization (DP=31 barg), mechanical damage and potential injuries to personnel/nitrogen accumulation inside building with asphyxiation hazard	223.5.2.1. Anti surge control system to open compressor by-pass valve (PCV) 223.5.2.2. USPM system to trip compressor in case of surge conditions 223.5.2.3. PSV-749 sized including this scenario			

Worksheet

Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect (cont.)	223. Misdirect Flow (cont.)	223.6. Unexpected opening of UV-763	223.6.1. Nitrogen partially routed to atmosphere (safe location) leading to lower suction pressure/flowrate for C7500/C7600 turbines boosters resulting in potential surge condition leading to turbines boosters damage and consequent extensive damage (major economical losses including operation disruption)/ possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)	223.6.1.1. Anti surge control system opening UV-760 223.6.1.2. PALL-750 activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760) 223.6.1.3. Oxygen monitoring inside building to give alarm (inside horn and outside light)			
			223.6.2. Loss of nitrogen to atmosphere resulting in reduced circulation of cooling medium resulting in loss of LNG production (see higher temperature in node #11)				

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	224. Lower Temperature	224.1. Malfunction of TIC-747 or TIC-748 increasing speed of fan E7400/E7401	224.1.1. Negligible impact on process side				
		224.2. Malfunction of TIC-754 or TIC-764 increasing speed of fan E7500/E7600	224.2.1. Negligible impact on process side				
		224.3. No causes identified for warm turbine T7500					
		224.4. No causes identified for cold turbine T7600 during normal operation					
		224.5. Start up in cold condition for cold turbine T7600 including malfunction of TIC-712 closing TV-712	224.5.1. Possible liquid nitrogen formation at turbine outlet resulting in potential damage to turbine impeller (economical losses including potential for major operation disruption)	224.5.1.1. TALL-714/713 activate closure of HV-710/712			
		224.6. Refer to More Level in node #31 for liquid nitrogen carry over from LNG subcooler from primary heat exchanger					

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	225. Higher Temperature	225.1. Malfunction of TIC-747 or TIC-748 reducing speed of fan E7400/E7401 or air coolers E7400/E7401 failure	225.1.1. Temperature build up on compressor second stage suction (approximately 106°C instead of 40°C) with potential overheating and mechanical damage (possible damage to impeller bearings and motor overload, economical losses)	225.1.1.1. TAHH-749/TAHH-3101 activate trip of compressor			TAHH-3101 represented in detailed P&ID of nitrogen compressor
			225.1.2. Higher temperature of nitrogen sent to downstream sections (DT = 65°C) with possible mechanical damage of piping overtime leading to loss of containment resulting in possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)/possible injuries due to contact with hot product	225.1.2.1. TAHH-749/TAHH-3101 activate trip of compressor 225.1.2.2. Oxygen monitoring inside building to give alarm (inside horn and outside light)			
			225.1.3. Higher temperature of stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating and consequent economical losses/operation...	225.1.3.1. TAHH-708 activate trip of compressor			

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	225. Higher Temperature (cont.)	225.1. Malfunction of TIC-747 or TIC-748 reducing speed of fan E7400/E7401 or air coolers E7400/E7401 failure (cont.)	...disruption	225.1.3.1. TAHH-708 activate trip of compressor (cont.)			
			225.1.4. Higher temperature of stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating leading to possible leakages of pressurized nitrogen inside cold box with potential overpressurization and mechanical damage (injuries to personnel)	225.1.4.1. TAHH-708 activate trip of compressor 225.1.4.2. Overpressure hatch provided on cold box			
		225.2. Loss of chilled water to HW7400	225.2.1. Higher temperature of nitrogen stream at the outlet of HW7400 (40°C instead of 10°C) with no impact on mechanical integrity downstream equipment				
			225.2.2. Loss of efficiency of primary heat exchanger resulting in higher temperature in node #11 (partial loss of LNG production)	225.2.2.1. TAHH-708 activate trip of compressor			
		225.3. Malfunction of TIC-754...	225.3.1. Higher temperature of...	225.3.1.1. Oxygen...	63. Relocate TAHH-752...	SIAD...	Additional...

Worksheet

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	225. Higher Temperature (cont.)	...or TIC-764 reducing speed of fan E7500/E7600 or air coolers E7500/E7600 failure	...stream routed to downstream systems leading to possible overheating on downstream sections leading to loss of containment resulting in possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)/possible injuries due to contact with hot product	...monitoring inside building to give alarm (inside horn and outside light)	...downstream E7500 and TAHH-762 downstream E7600 64. Consider to review DT of piping dowstream aircoolers E7400/7401/7500/7600 taking into account air cooler failure scenario	...MI SIAD MI	...temperature monitoring at warm and cold boosters outlet is provided as per scope of work of relevant manufacturer (see detailed machine P&ID)
			225.3.2. Higher temperature of stream routed to cold booster C7600 inlet (approximately 90°C instead of 40°C) and potential damage due to overheating and economical losses		:See 63		Action of TAHH-752 is to close quick closing valves HV-710/712
			225.3.3. Higher temperature of stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating and consequent economical losses/operation disruption	225.3.3.1. TAHH-709 activate closure of HV-710/712			
			225.3.4. Higher temperature of...	225.3.4.1. TAHH-709...			

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	225. Higher Temperature (cont.)	225.3. Malfunction of TIC-754 or TIC-764 reducing speed of fan E7500/E7600 or air coolers E7500/E7600 failure (cont.)	...stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating leading to possible leakages of pressurized nitrogen inside cold box with potential overpressurization and mechanical damage (injuries to personnel)	...activate closure of HV-710/712 225.3.4.2. Overpressure hatch provided on cold box			
		225.4. Loss of chilled water to HW7601	225.4.1. Higher temperature of nitrogen stream at the outlet of HW7601 (40°C instead of 10°C) with no impact on mechanical integrity downstream equipment				
			225.4.2. Loss of efficiency of primary heat exchanger resulting in higher temperature in node #11 (partial loss of LNG production)	225.4.2.1. TAHH-709 activate closure of HV-710/712			
		225.5. Malfunction of TIC-712 opening TV-712 when not required	225.5.1. Higher temperature of HPN stream to cold turbine stream resulting in slight reduction of efficiency for cold turbine	225.5.1.1. Event detectable by TI-714/713			

Worksheet

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Pressure
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	226. Lower Pressure	226.1. Refer to no/less and misdirect flow					
More	227. Higher Pressure	227.1. Refer to no/less flow					
		227.2. Malfunction of PIC-740A fully opening PV-740A on nitrogen make-up	227.2.1. Pressure build up overtime on compressor suction side with consequent possible mechanical stress and damage to rotating parts of first stage (economical losses)	227.2.1.1. Independent pressure monitoring at compressor suction including high high pressure trip (see detailed compressor P&ID)			
				227.2.1.2. PSV-741 sized including this scenario			
			227.2.2. Pressure build up overtime on compressor suction side with no impact on mechanical integrity of piping and compressor casing according to design criteria				
		227.3. Malfunction of PCV-736 (fully opening)	227.3.1. Nitrogen sent to cold box casing at 10 barg instead of 0,2 barg with potential overpressurization, mechanical damage and economical...	227.3.1.1. Pressure monitoring on cold box			
				227.3.1.2. Overpressure hatch provided on cold box			

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Pressure
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	227. Higher Pressure (cont.)	227.3. Malfunction of PCV-736 (fully opening) (cont.)	...losses/injuries to personnel	227.3.1.2. Overpressure hatch provided on cold box (cont.)			
		227.4. Thermal expansion of trapped liquid/cold gas	227.4.1. Possible mechanical damage on involved pipe/equipment	227.4.1.1. PSV-706 (pass N), PSV-709 (pass HPN2) on nitrogen side to protect primary exchanger 227.4.1.2. PSV-763 on HW7601 shell side 227.4.1.3. PSV-746 on HW7004 shell side			

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Level
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	228. No/less Level	228.1. Not applicable					
More	229. Higher Level	229.1. Not applicable					

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Intention: HX7000: OTin = -168 °C, OTout = 8,1 °C
C7400: OPsuction = 6,1 barg, OPdischarge = 28,3 barg
E7400/E7401: OTin = 126 °C, OTout = 40 °C
C7500: OPsuction = 28,2 barg, OPdischarge = 42 barg
E7500: OTin = 88,2 °C, OTout = 40 °C
C7600: OPsuction = 41,9 barg, OPdischarge = 69 barg
E7600: OTin = 105,4 °C, OTout = 40 °C
HW7601: OTin = 40 °C, OTout = 10 °C
CB7000: OTin = 10 °C, OTout = - 160 °C
T7600: OPsuction = 68,4 barg, OPdischarge = 6,6 barg
Notes:
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Composition
Equipment: CB7000, SE7400, C7400, E7400, E7401, C7500, E7500, C7600, E7600, HW7601, SE7500, T7600

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	230. Different Composition	230.1. No causes identified for make-up nitrogen (supplied by cryogenic storage)					

Worksheet

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Flow

Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	231. No/less Flow	231.1. Malfunction of LIC-719 closing LV-719	231.1.1. No significant consequences expected on Nitrogen compressor since liquid stream to LNG subcooler SC7001 is approximately 2.5% of overall compressor capacity				
			231.1.2. No liquid nitrogen carry over from HPN2_2 is expected since according to operating condition liquid nitrogen vaporizes in HPN2_2				
			231.1.3. Loss of cooling medium circulation through SC7001 with partial loss of LNG production (operation disruption/economical losses)	231.1.3.1. Event detectable by TI-718 231.1.3.2. LALL-720 activate closure of HV-700			
		231.2. Malfunction of PIC-719 closing PV-719	231.2.1. Pressure build up in SC7001 leading to potential overpressurization (DP=8 barg) with mechanical damage and consequent economical losses/operation disruption (LNG subcooler is located within cold box)	231.2.1.1. PAHH-722 activate closure of HV-700 231.2.1.2. PSV-718 sized including this scenario			
			231.2.2. Pressure build up in SC7001 leading to potential overpressurization (DP=8 barg) with mechanical damage and consequent leakage of liquefied nitrogen inside cold box leading to vaporization and potential...	231.2.2.1. PAHH-722 activate closure of HV-700 231.2.2.2. PSV-718 sized including this scenario 231.2.2.3. Overpressure...			

Worksheet

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Flow
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	231. No/less Flow (cont.)	231.2. Malfunction of PIC-719 closing PV-719 (cont.)	...overpressurization of cold box with mechanical damage (injuries to personnel)	...hatch on cold box			
		231.3. No causes identified for subcooler bottom line (NNF)					
More	232. More Flow	232.1. No causes identified					
Reverse	233. Reverse Flow	233.1. No causes identified					
Misdirect	234. Misdirect Flow	234.1. Inadvertent opening of HV-720	234.1.1. Nitrogen vaporized and sent to safe location with loss of nitrogen and economical losses		65. Provide a PLC function to not allow manual selection of HV-720 if plant is detected in operating mode	SIAD MI	
			234.1.2. Nitrogen vaporized and sent to safe location with loss of nitrogen with loss of level in SC7001 (loss of cooling medium through SC7001) with partial loss of LNG production (operation disruption/economical losses)	234.1.2.1. LALL-720 activate closure of HV-700			

Worksheet

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Temperature
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	235. Lower Temperature	235.1. No causes identified					
More	236. Higher Temperature	236.1. See No/Less flow in this node					

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Pressure
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	237. Lower Pressure	237.1. Malfunction of PIC-719 fully opening PV-719	237.1.1. Increased consumption of liquid nitrogen with slight reduction of efficiency of liquefaction loop	237.1.1.1. Event detectable by PI-722			
More	238. Higher Pressure	238.1. Refer to no/less flow in this node					
		238.2. Malfunction of LIC-719 wide opening LV-719	238.2.1. Sudden increase of two phase flow (OP=70 barg) of nitrogen stream to LNG subcooler (DP = 8 barg) leading to potential overpressurization, mechanical damage and injuries to personnel	238.2.1.1. PSV-718 sized for this scenario			PAHH-722 would not be 100% effective in this case to prevent overpressurization
		238.3. External fire/Thermal expansion	238.3.1. Overpressurization of involved equipment/piping with possible mechanical damage	238.3.1.1. PSV-718 sized including this scenario			

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Level
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	239. No/less Level	239.1. Refer to no/less and misdirect flow in this node					
More	240. Higher Level	240.1. Malfunction of LIC-719 opening LV-719 more than required	240.1.1. No impact on LNG temperature since LNG subcooler operates submerged				
			240.1.2. Level build up in SC7001 resulting in possible overfilling and consequent liquid nitrogen carry over to main exchanger HX7000 resulting in lower temperature affecting recycling nitrogen stream to compressor suction (lower temperature of this stream) possibly damaging the compressor due to thermal stress (economical losses)	240.1.2.1. LAHH-720 activate closure of HV-700 (leading to trip of turbine through quick closure valve HV-710 and HV-712) 240.1.2.2. TALL-707 activate trip of compressor C7400			

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Composition
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	241. Different Composition	241.1. No causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Intention: T7500: OPsuction = 28,12 barg, OPdischarge = 6,5 barg
HW7400: OTin = 40 °C, OTout = 10 °C
HX7000: OTin = -160,42 °C, OTout = 8,1 °C
Notes:
Drawings: I20784 Sh 23
Parameter: Services / Utilities
Equipment: SC7001, E7001, T7500, HW7400, HX7000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No	242. No Services / Utilities	242.1. No additional causes identified					

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Flow
Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	243. No/less Flow	243.1. Unexpected closure of HV-1700 or unexpected closure of KV-1700 A/B	243.1.1. No impact on upstream nitrogen storage tank				
			243.1.2. Possible overheating of nitrogen back-up trim heater H17000 with possible damage of electrical bundles (economical losses)	243.1.2.1. TAHH-1700 activate trip of H17000			
			243.1.3. Loss of nitrogen to loading bay for purging purposes (see relevant node #13) resulting in delay in loading operation (stop of loading phase)	243.1.3.1. PAL-1711			
			243.1.4. Unavailability of back-up nitrogen on demand resulting in delay on compressor start-up	243.1.4.1. PAL-1711			
		243.2. Unexpected closure of TV-1705	243.2.1. No impact on upstream nitrogen storage tank				
			243.2.2. Possible overheating of nitrogen back-up trim heater H17000 with possible damage of electrical bundles (economical losses)	243.2.2.1. TAHH-1700 activate trip of H17000			
			243.2.3. Loss of nitrogen to loading bay for purging purposes (see relevant node #13) resulting in delay in loading operation (stop of loading phase)	243.2.3.1. PAL-1711			
			243.2.4. Unavailability of back-up nitrogen on demand resulting in...	243.2.4.1. PAL-1711			

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Flow Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less (cont.)	243. No/less Flow (cont.)	243.2. Unexpected closure of TV-1705 (cont.)	...delay on compressor start-up	243.2.4.1. PAL-1711 (cont.)			
		243.3. Loss of level in nitrogen storage tank	243.3.1. Possible overheating of nitrogen back-up trim heater H17000 with possible damage of electrical bundles (economical losses)	243.3.1.1. Each LIN tank is provided with low level alarm and level gauge 243.3.1.2. TAHH-1700 activate trip of H17000			
			243.3.2. Loss of nitrogen to loading bay for purging purposes (see relevant node #13) resulting in delay in loading operation (stop of loading phase)	243.3.2.1. Each LIN tank is provided with low level alarm and level gauge 243.3.2.2. PAL-1711			
			243.3.3. Unavailability of back-up nitrogen on demand resulting in delay on compressor start-up	243.3.3.1. Each LIN tank is provided with low level alarm and level gauge 243.3.3.2. PAL-1711			
		243.4. Loss of nitrogen supply to cold flare header due to compressor shut down	243.4.1. Inadequate purging of cold flare header leading to potential for ambient air entrainment and consequent formation of flammable mixture inside cold flare header with potential explosion hazard	243.4.1.1. Back-up nitrogen injection to cold flare header through PCV-1708 243.4.1.2. Status of TV-1702 reported to DCS			
More	244. More Flow	244.1. Higher demand rate during emergency shut down	244.1.1. Possible inadequate purging of equipment/piping	244.1.1.1. Sequence to open KV stand by valve (to operate both vaporizers in parallel mode) and to open HV-1702			

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Flow
Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Reverse	245. Reverse Flow	245.1. No cause identified					
Misdirect	246. Misdirect Flow	246.1. KV-1700A/B stuck in open position during vaporizer switch over (every 8 hours)	246.1.1. Inadequate ice removal from vaporizer left in service, during normal operation according to limited flowrate of LIN through vaporizers, no significant consequences are expected	246.1.1.1. Discrepancy alarm on KVs			
		246.2. Unexpected opening of HV-1702	246.2.1. Nitrogen sent to cold flare header when not required leading to increased back pressure on LIN stream through primary exchanger with consequent reduced efficiency. Minor economical losses due to loss of nitrogen to cold flare	246.2.1.1. Discrepancy alarm on HVs			
		246.3. Malfunction of PCV-1708 (fully opening)	246.3.1. Nitrogen sent to cold flare header when not required leading to increased back pressure on LIN stream through primary exchanger with consequent slight reduction of efficiency. Negligible impact				The purpose of PCV-1708 is to segregate nitrogen stream on primary exchanger (vaporized LIN in cold box) from back-up nitrogen
		246.4. Unexpected opening of HV-1701	246.4.1. No consequences as long as instrument air system is working properly (OP=7 barg vs set point of PCV-1712 = 5 barg)				

Worksheet

Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Temperature
Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	247. Lower Temperature	247.1. Higher LIN demand rate during maintenance (cold box defrosting)	247.1.1. Lower temperature of nitrogen downstream vaporizer E17002A/B with possible damage of piping downstream TV-1702 and TV-1705 due to embrittlement with possible injuries to personnel/economical losses	247.1.1.1. TALL-1707 activate closure of HV-1700			
		247.2. Failure of H17000 including TIC-1703 malfunction reducing heat input to H17000	247.2.1. Lower temperature of nitrogen downstream heater H17000 with possible damage of piping downstream TV-1702 and TV-1705 due to embrittlement with possible injuries to personnel/economical losses	247.2.1.1. TALL-1704 activate closure of TV-1702 and TV-1705			
More	248. Higher Temperature	248.1. Refer to no/less flow in this node					
		248.2. TIC-1703 malfunction increasing heat input to H17000	248.2.1. Possible overheating of nitrogen back-up trim heater H17000 with possible damage of electrical bundles (economical losses)	248.2.1.1. TAHH-1700 activate trip of H17000			
			248.2.2. Higher temperature of nitrogen stream at outlet of H17000 with no impact during normal operation. Possible damage to turbine seal package during shut-down/start-up (economical losses)	248.2.2.1. TAHH-1700 activate trip of H17000	66. Add a high high temperature interlock initiated by TI-1704 to trip H17000	SIAD MI	

Worksheet

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Pressure
Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	249. Lower Pressure	249.1. Refer to no/less flow in this node					
More	250. Higher Pressure	250.1. Malfunction of PCV-1712 (fully open)	250.1.1. During normal operation pressure build up to 10 barg between PCV-1712 and HV-1701. No impact on mechanical integrity according to design criteria. Possible nitrogen losses to atmosphere due to intervention of PSV-1713 set at 10 barg		67. Increase set point of PSV-1713 at 13 barg (to guarantee also protection for fire scenario according to pipe schedule)	SIAD MI	
			250.1.2. In case nitrogen is required as back-up for instrument air, possible pressure build up on instrument air pipe up to 10 barg. No impact on mechanical integrity according to design criteria.				
		250.2. Malfunction of PCV-742 (fully open)	250.2.1. Possible pressure build up on seal gas line between PCV-742 and next PCV included on compressor package. No impact on mechanical integrity according to design criteria.	250.2.1.1. PAH2100 on compressor package			Refer to detailed P&ID of nitrogen compressor
		250.3. Malfunction of PCV-743 (fully open)	250.3.1. Higher consumption of back up nitrogen with no significant impact				
		250.4. External fire/Thermal expansion	250.4.1. Possible overpressurization of involved equipment/piping	250.4.1.1. All isolatable equipment/piping are protected by PSVs sized for fire or thermal expansion case depending on...			

Worksheet

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Pressure Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	250. Higher Pressure (cont.)	250.4. External fire/Thermal expansion (cont.)	250.4.1. Possible overpressurization of involved equipment/piping (cont.)	...relevant service			

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Level Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	251. No/less Level	251.1. Not applicable					
More	252. Higher Level	252.1. Not applicable					

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Intention: H17000: OTin = 10 °C, OTout (min/max) = -35/25 °C
E17002A/B: OTin (min/max) = -35/25 °C, OTout = -168 °C
Notes:
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Composition Equipment: E17002A/B, H17000

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	253. Different Composition	253.1. No causes identified					

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ATTACHMENT 4

HAZOP Action List

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Location: Renzenhof, Germany
Facility: LNG liquefaction plant
PHA Method: HAZOP
PHA Type: Initial

Process:

File Description:

Date:

Process Description:

Chemicals:

Purpose:

Scope:

Objectives:

Project Notes:

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (00) General issues
Drawings:
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect	1. Misdirect Flow	1.1. Inadvertent opening of vent valve on NG circuit to hot flare	1.1.1. Potential overpressurization of hot flare header		1. Mode of operation of hot flare and potential overpressurization scenario due to inadvertent opening of manual vent valves to be investigated once design of hot flare will be finalized (e. g. increasing DP of hot flare header, etc...)	SIAD MI / OGE	
			1.1.2. Possible unexpected routing of gas to hot flare when not in operation with possible environmental concern/ complains from authorities		2. Appropriate isolation philosophy to be investigated for drains and vents on LNG/NG high pressure vents and drains to hot flare used for maintenance purposes only	SIAD MI / OGE	

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Drawings: I20784 Sh 10
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	6. Lower Temperature	6.2. Failure of heater W-B41 or failure of relevant temperature control system (TT-B40621)	6.2.1. Lower temperature of natural gas at the outlet of fiscal metering station (estimated -2 °C instead of 10°C) with no impact on mechanical integrity of piping and potential operational upset on downstream sections.		3. Ensure that signal from TT-B41320 and TT-B42320 are reported to DCS including high and low temperature alarm	OGE (TPG)	
More	7. Higher Temperature	7.2. Higher heat input from heater W-B41 due to failure of relevant temperature control system (TT-B40621)	7.2.1. Increase of natural gas temperature and potential overheating of downstream piping (DT=80°C) with potential mechanical damage and loss of containment (possible fire/explosion)	7.2.1.1. Internal independent high high temperature interlock provided for heater W-B41 (Minimum requirement included on data sheet for vendor)	4. Ensure provision for internal independent high high temperature interlock provided for heater W-B41 to protect heater itself and downstream piping from overheating scenario	OGE (TPG)	

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Drawings: I20784 Sh 10
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	9. Higher Pressure	9.3. PCV-B41540 malfunction (fully open), including PT-B40622 malfunction	9.3.1. Pressure build-up dowstream valve PCV-B41540 up to 65 barg and potential overpressurization (DP=52 barg) with mechanical damage, loss of containment and potential for fire/explosion	9.3.1.1. SSV-B41520/B41530 (mechanical/pneumatical devices to cut off natural gas supply)	5. Ensure adequate set point for SSV-B41520/B41530 intervention to prevent opening of PSVs located on downstream piping (set at 52 barg)	OGE (TPG)	
		9.4. PCV-610 malfunction (fully open)	9.4.1. Higher pressure of natural gas routed to analyser (44 barg instead of 1 barg) with potential overpressurization of analysers (AI-1001, 1010, 1011, 1016) and associated items (DP= 0.5 barg) with mechanical damage and potential injuries to personnel		6. Ensure provision for pressure release devices to protect analysers AI-1001, 1010, 1011, 1016 and associated items in case of wide opening of pressure let down valve PCV-610/602	SIAD MI	Tubing and first valve downstream PCV-610 are rated to withstand 65 barg

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01A) Fiscal metering station
Drawings: I20784 Sh 10
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	9. Higher Pressure (cont.)	9.5. External fire	:		7. Investigate requirement for pressure relief devices for external fire case in compliance with criteria adopted for production plant	OGE (TPG)	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (1) 27/03/2023
Node: (01B) Natural gas supply, preheating, HG removal and absorption
Drawings: 2220698-0C-10-001 Sh 2; I20784 Sh 10; I20784 Sh 15
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	21. Lower Temperature	21.3. Low ambient temperature	21.3.1. Possible freezing of stagnant piping on rich amine side	21.3.1.1. Electrical tracing and insulation provided on rich amine piping (electrical tracing also supplied by EDG)	8. Investigate appropriate monitoring system to check functionality/effectiveness of electrical tracing systems	SIAD MI	

Action Items

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	62. Lower Temperature	62.2. Low ambient temperature	62.2.1. Possible freezing of stagnant piping on condensate side	62.2.1.1. Electrical tracing and insulation provided on condensate piping (electrical tracing also supplied by EDG)	9. Provide winterization on low points where condensation may happen on naturale gas line from TW1002 to HW4001	SIAD MI	

Session: (2) 28/03/2023
Node: (04) NG stream to dryers and condensate separator
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 5
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	66. Lower Level	66.1. Malfunction of LIC-419 fully opening LV-419	66.1.1. Loss of level on ST-4001 and consequent gas breakthrough (44 barg) to flash vessel S1003 (DP=10 barg) leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage	66.1.1.1. LALL-472 activate closure of LV-413 66.1.1.2. PSV-167 on S1003 sized including gas breakthrough scenario	10. Closure of LV-413 shall be also initiated by PAHH-172	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (05) MDEA Storage tank and dosing
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	77. No/less Level	77.1. Unappropriate monitoring of level in IBC	77.1.1. Emptying of IBC during fresh amine transfer and potential damage to P3001 due to dry running, economical losses		11. Provide additional gauging system to monitor level inside amine IBC (e.g. pressure gauge on bottom outlet line to P3001 pump suction, etc.)	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	81. No/less Flow (lean amine to TW1002)	81.2. Malfunction of FIC-227 to reduce rpm of pump P2005A/B through relevant VFD	81.2.1. Reduced of lean amine supply to TW1002 and consequent inadequate CO2 removal and consequent CO2 slippage to cold box (see relevant node)	81.2.1.1. AI-1012 to provide a high CO2 concentration alarm and to close HV-700 on high high CO2 concentration through ESD	12. Add a low pressure alarm to PI-201A/B	SIAD MI	
	83. No/less Flow (Overhead circuit)	83.1. Malfunction of PIC-275 closing PV-275 on CO2 vent to thermal oxidizer	83.1.1. Pressure build up on TW2008 and S2011 (DP=2barg) leading to potential overpressurization overtime, mechanical damage and injuries to personnel	83.1.1.1. PAHH-282 activate closure of FV-204 83.1.1.2. PSV-271 sized including this scenario	13. Add closure of LV-151 among actions initiated by PAHH-282 14. Investigate appropriate routing of PSV-271 (currently routed to atm at safe location) taking into account either potential presence of amine and requirements from national regulation	SIAD MI SIAD MI / OGE	
	84. No/less Flow (Bottom circuit)	84.1. Failure of pump P2012A/B	84.1.1. Level build up in S2011 leading to possible overfilling resulting in HW2010 flooding, loss of condensation and pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, damage and injuries to personnel	84.1.1.1. Discrepancy signal from onduty P2012A/B starting stand-by pump 84.1.1.2. LAHH-279 activate closure of FV-204 (same action is initiated by PAHH-282) 84.1.1.3. PSV-271 sized including this scenario	15. Add closure of LV-151 among actions initiated by LAHH-279	SIAD MI	
Reverse	86. Reverse Flow	86.1. Failure of pump P2005A/B	86.1.1. Possible natural gas reverse flow from TW1002 (44barg) to TW2008 (DP=2barg) leading to pressure build up in stripping column, mechanical damage and potential for...	86.1.1.1. Discrepancy signal from onduty P2005A/B starting stand-by pump	16. Add dedicated interlock to shut down HV-138 in case of back flow due to both P2005A/B not running (e.g. high high pressure detected on...	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (2) 28/03/2023
Node: (06) MDEA stripping column
Drawings: 2220698-0C-10-001 Sh 2; 2220698-0C-10-001 Sh 3; I20784 Sh 15
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Reverse (cont.)	86. Reverse Flow (cont.)	86.1. Failure of pump P2005A/B (cont.)	...injuries to personnel including fire/explosion hazard	86.1.1.1. Discrepancy signal from onduty P2005A/B starting stand-by pump (cont.)	...common pump suction line) 17. Add additional check valve dissimilar type at lean amine injection line in TW1002	 SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	96. More Flow	96.1. Operator mistake starting simultaneous drainage of different equipment	96.1.1. Possible level increase in V3004 leading to possible overfilling and amine release from vent line with possible injuries to personnel/soil contamination	96.1.1.1. Specific maintenance procedures which foresees single drainage at once 96.1.1.2. LAH/LAHH-305 activate trip of pump P3002 (used for equipment drainage) 96.1.1.3. MDEA blowdown tank located inside curbed area with adequate impermeable material	18. Provide overflow line for V3004 discharging to ground (located below inlet nozzle of PSV header)	SIAD MI	
Reverse	97. Reverse Flow	97.1. Failure of pump P3002 during trasfer to truck	97.1.1. Possible reverse flow from truck to MDEA blow down tank with negligible impact (delay in operation). Overfilling is not expected according to tank elevation.		19. Add check valve on P3002 discharge line to truck loading (downstream recirculation line)	SIAD MI	
Misdirect	98. Misdirect Flow	98.2. Inadvertent opening of valve X318 or valve passing	98.2.1. Possible contamination of fresh amine and consequent operational upset		20. Specify NC valve X307 on IBC bottom	SIAD MI	

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	100. Higher Temperature	100.1. Operator mistake draining hot amine from TW2008 bottom (120 °C)	100.1.1. Possible overheating of V3004 (DT=60°C) resulting in mechanical damage and possible leakages (injuries to personnel/economical losses)	100.1.1.1. Specific drainage procedure which foresees adequate amine cooling before transfer to V3004 100.1.1.2. TAL-214 to give permission to pump...	21. Relocate TAL to give permission to pump P3002 to start from TT-214 to TT-127 22. Review V3004 design temperature up to 100 °C	SIAD MI SIAD MI	

Action Items

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	100. Higher Temperature (cont.)	100.1. Operator mistake draining hot amine from TW2008 bottom (120 °C) (cont.)	100.1.1. Possible overheating of V3004 (DT=60°C) resulting in mechanical damage and possible leakages (injuries to personnel/economical losses) (cont.)	...P3002 to start only if temperature is adequate for transfer to blowdown tank	22. Review V3004 design temperature up to 100 °C (cont.)		

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	102. Higher Pressure	102.2. Pump P3002 blocked outlet condition	102.2.1. Pressure buil up on blocked in piping (including flexible hoses) up to pump sut-off pressure (approximately 4 barg). No impact on mechanical integrity of piping according to design criteria. Possible overpressurization of flexible hose resulting in amine solution leak and possible injuries to personnel/soil contamination		23. Ensure that flexible hoses used for amine transfer to truck have adequate design pressure to cope with shut-off pressure of P3002	OGE (TBF)	

Session: (3) 29/03/2023
Node: (07) MDEA blowdown tank
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 4
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	103. No/less Level	103.1. Operator does not stop P3002 on low level in V3004 (including LT-305 failure)	103.1.1. Possible damage to P3002 due to dry running with minor economical losses and delay in operation	103.1.1.1. LALL-305 activate the trip of pump (not effective in case of LT-305 failure) 103.1.1.2. Event detectable by PI-306 (operator is in place during transfer)	24. Add a level gauge on V3004	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (08) Antifoam dosing package
Drawings: 2220698-0C-10-001 Sh 3
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	113. Higher Pressure	113.1. Blocked outlet for P2013	113.1.1. Possible damage to pump (economical losses)/potential overpressurization of downstream piping resulting in mechanical damage and potential injuries to personnel	113.1.1.1. Specific provedure for line up of antifoam agent injection line	25. Add pressure relief device on P2013 discharge line, sized for blocked outlet scenario	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect	120. Misdirect Flow	120.3. Unexpected opening of HV-705	120.3.1. Natural gas sent to cold flare with environmental concern	120.3.1.1. Discrepancy alarm on HVs 120.3.1.2. PDAHH-708 activate closure of HV-600 and HV-602	26. Specify FO valve HV-705 since it is blow down valve for emergency purposes	SIAD MI	

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	122. Higher Temperature	122.1. Loss of chilled water to HW4002	122.1.1. Natural gas routed to downstream equipment at 25°C instead of 10°C resulting in reduction of efficiency in liquefaction process	122.1.1.1. TI-485	27. Add a high temperature alarm on TI-485	SIAD MI	

Session: (3) 29/03/2023
Node: (09) Natural gas precooling, drying and liquefaction
Drawings: 2220698-0C-10-001 Sh 5; I20784 Sh 15; I20784 Sh 20
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	124. Higher Pressure	124.1. PCV-700 malfunction (fully open)	124.1.1. Higher pressure of natural gas routed to analyser (44 barg instead of 1 barg) with potential overpressurization of analysers (AI-1013A, 1012) and associated items (DP= 0.5 barg) with mechanical damage and potential injuries to personnel		28. Ensure provision for pressure release devices to protect analysers AI-1013A, 1012 and associated items in case of wide opening of pressure let down valve PCV-700	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (3) 29/03/2023
Node: (10) Natural gas dryers regeneration loop
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	132. No/less Flow (compressor discharge)	132.3. Unexpected closure of HV-511	132.3.1. Unavailability of bleed valve on demand		29. Specify HV-511 as FO valve	SIAD MI	
Misdirect	135. Misdirect Flow	135.4. Unexpected opening of TV-530B	135.4.1. During dryer heating mode, higher temperature of natural gas to downstream section (220°C instead of 10°C) due to by-pass of HW5000, with possible overheating (DT=65°C for EW5000) resulting in mechanical damage and possible leak of natural gas with possible fire		30. Add a high high temperature interlock initiated by TI-535 to close TV-530B	SIAD MI	
		135.5. Tube rupture in HW5000	135.5.2. In case of possible natural gas entrainment in chilled water circuit no significant consequences are expected during normal operation; accumulation of natural gas can lead to potential exposure of maintenance operator to flammable mixture		31. Maintenance procedure for chilled water circuit shall include actions and safeguards to avoid personnel exposure to natural gas possibly present	OSE (TZSA)	
		135.7. Inadvertent opening of separators drain valve	135.7.1. Potential operational upset due to unexpected trip of compressor due to PALL intervention/leakage of NG and potential for personnel exposure to fire/explosion hazards		32. Specify manual valves on recycle gas compressor separators drains as LC	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	137. Higher Temperature	137.6. Malfunction of TIC-555 fully opening TV-555	137.6.1. Higher temperature (up to 100°C) of regeneration gas to compressor resulting in possible overheating of EW5000 process gas coils (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		33. Review design temperature of EW5000 process gas coils up to 100°C	SIAD MI	
		137.9. Loss of cooling water to HW5503	137.9.1. Higher temperature of natural gas (estimated approximately 137°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		34. Add a high high temperature interlock downstream HW5503 to activate trip of compressor C5500	SIAD MI	

Session: (4) 30/03/2023
Node: (10) Natural gas dryers regeneration loop
Drawings: 2220698-0C-10-001 Sh 3; 2220698-0C-10-001 Sh 5; I20784 Sh 10; I20784 Sh 15; I20784 Sh 36; I20784 Sh 37; I20784 Sh 37A; I20784 Sh 37B; I20784 Sh 39B
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	140. No/less Level	140.4. Malfunction of LIC-501A not closing DV-501 on demand	140.4.1. Natural gas at 4.9 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire	140.4.1.1. LALL-501B activate closure of HV-515	35. Investigate additional safeguard to prevent overpressurization in S2011 in case of gas breakthrough from C5500 compressor separators (e.g. PSV routed to cold flare located downstream HV-515, additional PAHH on drain line to S2011 acting on additional on/off valve etc..)	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (4) 30/03/2023
Node: (11) LNG separator
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	144. No/less Flow	144.5. Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV-1913A/B	144.5.4. Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with consequent vaporization resulting in pressure build up in EW9000 and associated piping (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages with possible injuries to personnel (fire/explosion hazard)	144.5.4.1. LAHH-716 activate closure of HV-700 (same actions activated by PAHH-717) 144.5.4.2. PSH-715A activate opening HV-715 to cold flare KO drum V16000 144.5.4.3. Overpressure device provided on cold box	36. PSV-914 shall be verified for LNG vaporization in EW9000	SIAD MI	
Reverse	146. Reverse Flow	146.1. Shut-down of thermal oxidizer	146.1.1. Possible CO2 stream at 0,9 barg (from S2011) back flow from V16200 to LNG separator S7003 (OP = 0,5 barg) leading to possible LNG contamination and off spec products		37. PAHH-1640 shall close HV-1646 to avoid LNG contamination by CO2 in case of thermal oxidizer shut-down possibly leading to CO2 backflow from V16200 to LNG separator S7003	SIAD MI	
Misdirect	147. Misdirect Flow	147.2. Unexpected opening of HV-715	147.2.1. Possible continuous NG routed to cold flare with environmental concern and loss of product		38. Provide alarm on HZI-715 for loss of closed position of HV-715	SIAD MI	
		147.3. Unexpected opening of HV-711	147.3.1. LNG routed to cold flare KO drum V16000 resulting in KO drum overfilling and possible liquid carry over to cold flare resulting in LNG outflow from flare tips with potential injuries to personnel	147.3.1.1. Discrepancy alarm on HVs	39. Add a high high level interlock on V16000 to activate closure of HV-700 (relevant set point to be defined to allow adequate residual volume preventing overfilling after HV-700 closure)	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (11) LNG separator
Drawings: I20784 Sh 20; I20784 Sh 22; I20784 Sh 23; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 70
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	149. Higher Temperature	149.5. Malfunction of TIC-952 fully opening TV-952 on LP steam to EW9000	149.5.2. Higher temperature of water bath in EW9000 (max 100°C) with no impact on EW9000 and coils according to selected material (stainless steel)		40. Review design temperature of EW9000 from 90°C to 100°C	SIAD MI	
			149.5.3. Higher temperature of water bath in EW9000 leading to steam generation and consequent possible release from EW9000 atmospheric vent and potential injuries to personnel	149.5.3.1. TAH-953	41. Ensure safe location requirements of EW5000 and EW9000 atmospheric vent	SIAD MI	

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	162. Higher Temperature	162.4. Loss of cooling water to HW9103	162.4.1. Higher temperature of BOG recovery gas (estimated approximately 175°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire		42. Add a high high temperature interlock downstream HW9103 to activate trip of BOG compressor C9100	SIAD MI	

Session: (6) 03/04/2023
Node: (12) LNG storage tank including BOG loop
Drawings: I20784 Sh 10; I20784 Sh 30; I20784 Sh 31; I20784 Sh 38; I20784 Sh 38A; I20784 Sh 38B
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	164. Higher Pressure	164.2. External fire/Thermal expansion	164.2.1. Overpressurization of involved equipment/piping with possible mechanical damage	164.2.1.1. All isolatable equipment and piping on LNG sections are protected by pressure relief devices sized for this case	43. Provide additional pressure relief device against External fire/Thermal expansion on LNG build up line between last block valve and new HV	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	169. No/less Flow	169.4. Unexpected closure of HV-1951A, FV-1950A, HV-1952A	169.4.4. Potential pressure surge resulting in mechanical damage to LNG transfer line from pump to last on/off valve resulting in potential LNG leak and possible fire/explosion hazard		44. Surge study to be provided for LNG truck loading lines (including worst case scenario: closure of on/off valve on road tanker side)	SIAD MI	
		169.6. Unexpected closure of HV-1957A, PV-1958A, HV-1956A (when BOG is routed back to tank) or unexpected closure of PV-1959A, HV-1958A, FV-914 (when BOG from road tanker is routed to BOG compressor)	169.6.1. Pressure build up in road tanker up to shut-off pressure of pump P19000 (estimated <15 barg) and potential overpressurization leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel	169.6.1.1. PAHH-1960A to activate trip of pump P19000 and to close on/off pneumatic valve on truck inlet by means of SY-1950AA (same actions initiated also by PAHH-1961A, not effective only in case of blocked outlet on gas return line inside road tanker)	45. Set point of PAHH-1960A and PAHH-1961A shall be defined taking into account lowest design pressure for road tankers (design pressure of road tankers to be checked by OGE, currently available value is 7 barg)	OGE	
Misdirect	173. Misdirect Flow	173.5. HV-1954A / HV-1955A stuck in open position after end of purging operation	173.5.2. After the end of pressure test, in case of increased pressure on LNG loading / BOG lines, sequence will be stopped by PAHH-1960A / PAHH-1961A leading to delay in operation		46. Provide a PSV on nitrogen purging line to LNG / BOG lines (set at adequate value)	SIAD MI	

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	175. Higher Temperature	175.5. TIC-952 malfunction increasing heat input to EW9000	175.5.1. Higher temperature (up to 100°C) of BOG gas to compressor resulting in possible overheating of EW9000 process gas coils (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible...		47. Review design temperature of EW9000 coils up to 100°C	SIAD MI	

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More (cont.)	175. Higher Temperature (cont.)	175.5. TIC-952 malfunction increasing heat input to EW9000 (cont.)	...fire		47. Review design temperature of EW9000 coils up to 100°C (cont.)		

Session: (5) 31/03/2023
Node: (13) LNG tank and truck loading system
Drawings: I20784 Sh 30; I20784 Sh 32; I20784 Sh 34; I20784 Sh 38
Parameter: Other

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	182. Other Than Other	182.1. Hose failure	182.1.1. Release of LNG on loading area with possible fire/explosion hazard	182.1.1.1. PALL-1960A activate trip of pump P19000, close HV-1952A and SY-1950AA	48. Shut down of LNG loading shall be also activated by LNG high flow gradient according to requirement of TRGS 751 4.1.6 paragraph 6 codes	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Drawings: I20784 Sh 70
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	183. No/less Flow	183.4. Unexpected closure of HV-1645	183.4.1. Pressure build up in V16200 leading to increase back pressure for incoming streams (see blocked outlet scenario for node #11 and #06)		49. PAHH-1640 shall also close HV-1646 to segregate stripper condensate separator S2011 from heavy HC KO drum V16200	SIAD MI	
			183.4.3. Pressure build up in V16200 due to vaporization of liquid and possible overpressurization resulting in possible mechanical damage leading to injuries to personnel/leakages and fire hazard		50. PSV-914 shall be verified for blocked outlet condition on V16200	SIAD MI	
					51. PAHH-1640 shall also close HV-721 and trip H16200/H16201	SIAD MI	

Session: (7) 04/04/2023
Node: (14) Heavy HCs KO drum
Drawings: I20784 Sh 70
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	187. Lower Temperature	187.3. Failure on demand of H16201 including TDY-1644 malfunction to switch off H16201 or to not switch on on demand	187.3.1. Lower temperature of stream routed to thermal oxidizer inlet resulting in possible condensation and droplets carry over to thermal oxidizer leading to operational upset / possible damage		52. Investigate impact of liquid carry over to thermal oxidizer in case of unavailability of superheater H16201 or in case of loss of heater H16200	SIAD MI	
More	188. Higher Temperature	188.5. Malfunction of TDY-1644 to not switch off H16201 on demand or to switch on when not required	188.5.1. Higher temperature of gas routed to thermal oxidizer and potential for damage to internals (economical losses)		53. Relocate TI-1644 downstream H16201 and add a high high temperature interlock to trip H16201	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (14) Heavy HCs KO drum
Drawings: I20784 Sh 70
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	192. Higher Level	192.1. Failure on demand of H16200 including malfunction of LI-1641	192.1.1. Liquid accumulation on V16200 resulting in possible overfilling and liquid carry over to thermal oxidizer leading to operational upset/possible damage	192.1.1.1. LAHH-1640 activate trip of thermal oxidizer and close HV-1645	54. LAHH-1640 shall also close HV-1646 to prevent potential liquid backflow to S2011 and trip H16201 to prevent thermal expansion of trapped material	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Drawings: I20784 Sh 39A
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect	199. Misdirect Flow	199.2. Cold flare drain valve left open after maintenance or valve passing	199.2.1. Continuous leakage of nitrogen during normal operation. Potential hydrocarbon leak with fire hazard in case of relief on cold flare header		55. Provide additional positive isolation device on cold flare bottom drain line	SIAD MI	

Session: (7) 04/04/2023
Node: (15) LNG drain KO drum and cold flare
Drawings: I20784 Sh 39A
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Less	200. Lower Temperature	200.2. Low ambient temperature	200.2.1. In case of injection of snuffing gas (CO_2) potential condensation leading to potential mechanical damage of cold flare tip		56. Investigate if CO_2 is suitable for snuffing purpose on cold flare, taking into account minimum ambient temperature and possibility of condensation	SIAD MI	

Session: (8) 05/04/2023
Node: (20) Cooling water circuit
Drawings: I20784 Sh 50; I20784 Sh 51; I20784 Sh 65; I20784 Sh 66; I20784 Sh 67; I20784 Sh 68
Parameter: Composition

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Different	207. Different Composition	207.1. Injection of biocide agent	:		57. Properties of biocide agent and potential associated hazards to be investigated	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (22) Condensate collection
Drawings: I20784 Sh 10; I20784 Sh 16; I20784 Sh 37; I20784 Sh 38; I20784 Sh 50
Parameter: Level

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	211. Higher Level	211.1. Unavailability of condensate pump P15000	211.1.1. Level build up in condensate collection drum, leading to potential overfilling and release of hot condensate (85°C) from vent leading to possible injuries to personnel		58. Ensure condensate collection drum vent to be routed to safe location	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (8) 05/04/2023
Node: (24) Demi water package
Drawings: I20784 Sh 68
Parameter: Composition

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	215. High Concentration	215.1. Higher salt (conductivity) on reverse osmosis drain	215.1.1. Possible off spec stream to downstream treatment unit		59. Investigate potential impact of waste water from demi water package routed to waste water collection/treatment system	OGE (TPLT)	

Session: (8) 05/04/2023
Node: (24) Demi water package
Drawings: I20784 Sh 68
Parameter: Other

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Other Than	216. Other Than Other	216.1. Handling of chemicals harmful for eye and skin	216.1.1. Possible injuries to personnel in case of leakage		60. Investigate requirement for emergency showers/eye showers on demi water package due to presence of harmful chemicals	OGE (TZSA)	

Session: (6) 03/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
No/less	220. No/less Flow	220.6. Potential plugging of strainer on turbine boosters C7500/7600 suction	220.6.1. Slight reduction on turbine boosters C7500/7600 efficiency and consequent potential minor operational upset		61. Provide differential pressure measurements accross filters on turbine boosters C7500/7600 suctions by using existing instrumentation	SIAD MI	Additional temporary filter is provided for commissioning phase only. This temporary filter will be removed for normal operation as per SIAD commissioning procedure
		220.8. Potential plugging of strainer on turbine T7500/7600 suctions	220.8.1. Slight reduction on turbine T7500/7600 efficiency and consequent potential minor operational upset		62. Provide differential pressure measurements accross filters on turbines T7500/7600 suctions by using existing instrumentation	SIAD MI	Additional temporary filter is provided for commissioning phase only. This temporary filter will be removed for normal operation as per SIAD commissioning procedure

Session: (7) 04/04/2023
Node: (30) Liquid Nitrogen supply to cold box and nitrogen recycle compressor
Drawings: I20784 Sh 22; I20784 Sh 23; I20784 Sh 25; I20784 Sh 26; I20784 Sh 27; I20784 Sh 30; I20784 Sh 31
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	225. Higher Temperature	225.3. Malfunction of TIC-754 or TIC-764 reducing speed of fan E7500/E7600 or air coolers E7500/E7600 failure	225.3.1. Higher temperature of stream routed to downstream systems leading to possible overheating on downstream sections leading to loss of containment resulting in possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)/possible injuries due to contact with hot product	225.3.1.1. Oxygen monitoring inside building to give alarm (inside horn and outside light)	63. Relocate TAHH-752 downstream E7500 and TAHH-762 downstream E7600 64. Consider to review DT of piping dowstream aircoolers E7400/7401/7500/7600 taking into account air cooler failure scenario	SIAD MI SIAD MI	Additional temperature monitoring at warm and cold boosters outlet is provided as per scope of work of relevant manufacturer (see detailed machine P&ID)

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (6) 03/04/2023
Node: (31) LNG subcooler
Drawings: I20784 Sh 23
Parameter: Flow

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
Misdirect	234. Misdirect Flow	234.1. Inadvertent opening of HV-720	234.1.1. Nitrogen vaporized and sent to safe location with loss of nitrogen and economical losses		65. Provide a PLC function to not allow manual selection of HV-720 if plant is detected in operating mode	SIAD MI	

Action Items

Company: SIAD / OGE / BIOPLUS GmbH
Facility: LNG liquefaction plant

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Temperature

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	248. Higher Temperature	248.2. TIC-1703 malfunction increasing heat input to H17000	248.2.2. Higher temperature of nitrogen stream at outlet of H17000 with no impact during normal operation. Possible damage to turbine seal package during shut-down/start-up (economical losses)	248.2.2.1. TAHH-1700 activate trip of H17000	66. Add a high high temperature interlock initiated by TI-1704 to trip H17000	SIAD MI	

Session: (7) 04/04/2023
Node: (32) Liquid nitrogen vaporizers, nitrogen heater and distribution
Drawings: I20784 Sh 22; I20784 Sh 25; I20784 Sh 34; I20784 Sh 37A; I20784 Sh 38A; I20784 Sh 38B; I20784 Sh 40; I20784 Sh 41; I20784 Sh 42
Parameter: Pressure

GW	DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	BY	NOTES
More	250. Higher Pressure	250.1. Malfunction of PCV-1712 (fully open)	250.1.1. During normal operation pressure build up to 10 barg between PCV-1712 and HV-1701. No impact on mechanical integrity according to design criteria. Possible nitrogen losses to atmosphere due to intervention of PSV-1713 set at 10 barg		67. Increase set point of PSV-1713 at 13 barg (to guarantee also protection for fire scenario according to pipe schedule)	SIAD MI	

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ATTACHMENT 5

SIL Worksheet

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S1001		
Session/Date	#1/05/04/23			***Parameter***	Flow		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Misdirect		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 20.3		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PDAHH-105***	***#***	***1***
P&Id n.	2220698-0C-10-001 Sh 2	rev.	0C				

Safety Instrumented Function Description		
Initiator	PDT-105	
Logic Solver	-	ESD
Final elements	HV-105, HV-106	activate closure of HV-105, HV-106 in case of high high DP

Scenario description	
Initiating events	Unexpected opening of HV-164
Consequences	Significant portion of natural gas sent to cold flare resulting in possible environmental concern

SIL Allocation						
Consequences to People	**S**	S0 - No consequences	0	**SIL (People)**		-
Consequences to Environment	**E**	E2 - Release within the fence with significant damage	2			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**a**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	Discrepancy alarm on HVs and operator response
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	TW1002		
Session/Date	#1/05/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 25.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-144***	***#***	***2***
P&Id n.	2220698-0C-10-001 Sh 2	rev.	0C				

Safety Instrumented Function Description		
Initiator	LSLL-144	
Logic Solver	-	ESD
Final elements	LV-146	activate closure of LV-146

Scenario description	
Initiating events	Malfunction of LIC-152 fully opening LV-152 on TW1002 bottom side
Consequences	Loss of level on TW-1002 and consequent gas breakthrough (44 barg) to flash vessel S1003 (DP=10 barg) leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**a**

Notes	Same function is also initiated by PSHH-172
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-167 on S1003 sized including gas breakthrough scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	MDL6000		
Session/Date	#1/05/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 36.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-601***	***#***	***3***
P&Id n.	I20784 Sh 11	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-601	
Logic Solver	-	ESD
Final elements	HV-600	activate closure of HV-600

Scenario description	
Initiating events	Malfunction of pressure controller on feed gas module
Consequences	Higher pressure of natural gas at feed gas module outlet resulting in potential overpressurization, mechanical damage, natural gas leak and fire / explosion hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 1000	1000		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	Shut-off valves provided within MDL6000 as per national regulation (RRF=10) PSV-605 sized including this scenario (RRF=100)
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S1003		
Session/Date	#1/05/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 41.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-172***	***#***	***4***
P&Id n.	2220698-0C-10-001 Sh 2	rev.	0C				

Safety Instrumented Function Description		
Initiator	PSHH-172	
Logic Solver	-	ESD
Final elements	LV-146	activate closure of LV-146

Scenario description	
Initiating events	Malfunction of PIC-171 closing PV-171 or PV spurious closure
Consequences	Pressure build up in S1003 leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-167 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	TW2008		
Session/Date	#1/05/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 43.1, 92.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-209***	***#***	***5***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-209	
Logic Solver	-	ESD
Final elements	P-2005A/B	activate trip of pump P-2005A/B

Scenario description	
Initiating events	1) Malfunction of LIC-163 closing LV-163 or not opening on demand or spurious closure of LV-151 2) Malfunction of LIC202/TIC-272 leading to reduced condensation rate in HW2010/inadequate demi water make-up through TV-291
Consequences	Loss of level in TW2008 and potential damage to P-2005A/B due to dry-running with potential localized NG leakage due to backflow from TW1002 resulting in possible fire and injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**a**

Notes	
S selection	S2 selected taking into account additional check valve dissimilar type as per HAZOP Recommendation N 17
E selection	
F selection	
P selection	Presence of gas detection system including on site acoustic and visual alarm warning
W selection	
IPL	Additional high high pressure interlock provided on P2005A/B suction as per HAZOP Recommendation N 16, assumed RRF=10
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S1003		
Session/Date	#1/05/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 54.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-164***	***#***	***6***
P&Id n.	2220698-0C-10-001 Sh 2	rev.	0C				

Safety Instrumented Function Description		
Initiator	LSLL-164	
Logic Solver	-	ESD
Final elements	LV-151	activate closure of LV-151

Scenario description	
Initiating events	Malfunction of LIC-163 fully opening LV-163
Consequences	Loss of amine level on S1003 and consequent gas breakthrough (5 barg) to stripping column TW2008 (DP= 2 barg) with potential mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-271 sized including gas breakthrough scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	ST4001		
Session/Date	#1/05/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 66.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-472***	***#***	***7***
P&Id n.	2220698-0C-10-001 Sh 5	rev.	0C				

Safety Instrumented Function Description		
Initiator	LSLL-472	
Logic Solver	-	ESD
Final elements	LV-413	activate closure of LV-413

Scenario description	
Initiating events	Malfunction of LIC-419 fully opening LV-419
Consequences	Loss of level on ST4001 and consequent gas breakthrough (44 barg) to flash vessel S1003 (DP=10 barg) leading to potential overpressurization with mechanical damage and loss of containment of natural gas/rich amine, potential fire/explosion and injuries to personnel due to mechanical damage

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-167 on S1003 sized including gas breakthrough scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S2011		
Session/Date	#1/xx/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 83.1, 87.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-282***	***#***	***8***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-282	
Logic Solver	-	ESD
Final elements	FV-204, LV-151	activate closure of FV-204 and closure of LV-151

Scenario description	
Initiating events	1) Malfunction of PIC-275 closing PV-275 on CO2 vent to thermal oxidizer 2) Tube rupture in HW2009
Consequences	Pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, mechanical damage and injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**-**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**-**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**-**

Notes	See HAZOP Recommendation N 13: Add closure of LV-151 among actions initiated by PAHH-282
S selection	S2 selected considering low operating pressure and not hazardous materials presence
E selection	
F selection	
P selection	
W selection	
IPL	PSV-271 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S2011		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	More		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 84.1, 87.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH-279***	***#***	***9***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	LSHH-279	
Logic Solver	-	ESD
Final elements	FV-204, LV-151	activate closure of FV-204 and closure of LV-151

Scenario description	
Initiating events	1) Failure of pump P2012A/B 2) Malfunction of LIC-202 leading to unexpected opening of LV-291 on demi water supply to S2011
Consequences	Level build up in S2011 leading to possible overfilling resulting in HW2010 flooding, loss of condensation and pressure build up on TW2008 and S2011 (DP=2barg) leading to potential ovepressurization overtime, damage and injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**a**

Notes	Same action is initiated by PAHH-282
	See Recommendation N 15: Add closure of LV-151 among actions initiated by LAHH-279
S selection	S2 selected considering low operating pressure and not hazardous materials presence
E selection	
F selection	
P selection	
W selection	
IPL	PSV-271 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	TW2008		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 86.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH***	***#***	***10***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT	
Logic Solver	-	ESD
Final elements	HV-138	activate closure HV-138

Scenario description	
Initiating events	Failure of pump P2005A/B Loss of power supply
Consequences	Possible natural gas reverse flow from TW1002 (44barg) to TW2008 (DP=2barg) leading to pressure build up in stripping column, mechanical damage and potential for injuries to personnel including fire/explosion hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	New SIF from HAZOP Recommendation N 16: Add dedicated interlock to shut down HV-138 in case of back flow due to both P2005A/B not running (e.g. high high pressure detected on common pump suction line)
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected considering auto start of spare pump P2005A/B (Discrepancy signal from onduty P2005A/B starting stand-by pump)
IPL	IPL=10 taking into account HAZOP Recommendation N 17. Add additional check valve dissimilar type at lean amine injection line in TW1002
Selected SIL	

Action	1	Effectiveness of PSV-271 in case of back flow from TW1002 to TW2008 shall be verified considering presence of 2 check valves dissimilar type (reduced required discharge capacity according to reference standard API 521, chapter 4.4.9.3.3). If PSV is adequate, required SIL ca be derated by 1 level ensuring periodical testing on check valves. For this purpose it is suggested to install second dissimilar check valve on dedicated discharge line of each P2005A/B

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	H2001		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 89.6		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-211***	***#***	***11***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-211	
Logic Solver	-	ESD
Final elements	H2001	activate trip of heater H2001

Scenario description	
Initiating events	Blocked outlet condition for CO2 vent gas stream (PV275 closure)
Consequences	Possible overheating of H2001 and piping (DT = 90°C) with potential mechanical damage and loss of containment of hot product with personnel injuries

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	F2001/2/3		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 91.4		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-289***	***#***	***12***
P&Id n.	2220698-0C-10-001 Sh 3	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-289	
Logic Solver	-	ESD
Final elements	P-2005A/B	activate trip of P-2005A/B

Scenario description	
Initiating events	Malfunction of PCV-229 (fully open)
Consequences	Lean amine at 44 barg sent to F2001, F2002 and F2003 (DP = 8 barg) resulting in possible overpressurization, mechanical damage and injuries to personnel

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-203 sized for this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	V3004		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 96.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH-305***	***#***	***13***
P&Id n.	2220698-0C-10-001 Sh 4	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-305	
Logic Solver	-	ESD
Final elements	P3002	activate trip of pump P3002 (used for equipment drainage)

Scenario description	
Initiating events	Operator mistake starting simultaneous drainage of different equipment
Consequences	Possible level increase in V3004 leading to possible overfilling and amine release from vent line with possible injuries to personnel/soil contamination

SIL Allocation						
Consequences to People	**S**	S1 - Minor injuries	1	**SIL (People)**		-
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		-
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	-
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	-

Notes	
S selection	S1 selected considering HAZOP Recommendation N 18. Provide overflow line for V3004 discharging to ground (located below inlet nozzle of PSV header)
E selection	Curbed and paved area, material selection is adequate to avoid soil contamination
F selection	
P selection	
W selection	
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	MDL5000		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 120.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-528***	***#***	***14***
P&Id n.	I20784 Sh 36	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-528	
Logic Solver	-	ESD
Final elements	PV-527	activate closure of PV-527 (for depressurization circuit)

Scenario description	
Initiating events	Wrong position for any KV in the position between high pressure stream and low pressure stream
Consequences	Natural gas in operating mode (44 barg, 20 °C) routed to NG regeneration module (16 barg) resulting in possible overpressurization, mechanical damage and natural gas leak (possible fire/explosion)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**a**

Notes	Same considerations for PAHH-531 to active closure of PV-527 (for regeneration circuit)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-530 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	H4006		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 128.1, 129.1, 131.1, 131.3, 137.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-466***	***#***	***15***
P&Id n.	2220698-0C-10-001 Sh 5	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-466	
Logic Solver	-	ESD
Final elements	H4006	activate trip of heater H4006

Scenario description	
Initiating events	1) FIC-461 malfunction closing FV-461 or closure of any KV on regeneration gas loop 2) Unexpected closure of TV-530A 3) Unexpected closure of HV-500 4) Unexpected compressor stop (any cause) 5) Failure of TI-483 leading to higher heat input in H4006
Consequences	Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire/explosion hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	Same consideration applicable to TAHH-467 and TAHH-469
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	Independent temperature transmitter with high temperature alarm as per following action
Selected SIL	

Action	2	Provide an additional independent temperature transmitter at H4006 outlet with high temperature alarm

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	H4006		
Session/Date	#2/17/04/23			***Parameter***	Differential pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 128.1, 129.1, 131.1, 131.3		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PDALL-481***	***#***	***16***
P&Id n.	2220698-0C-10-001 Sh 5	rev.	0C				

Safety Instrumented Function Description		
Initiator	PDT-481	
Logic Solver	-	ESD
Final elements	H4006	activate trip of heater H4006

Scenario description	
Initiating events	1) FIC-461 malfunction closing FV-461 or closure of any KV on regeneration gas loop 2) Unexpected closure of TV-530A 3) Unexpected closure of HV-500 4) Unexpected compressor stop (any cause)
Consequences	Possible overheating of H4006 and piping (DT = 350°C) with potential mechanical damage and loss of containment of natural gas product with personnel injuries/fire explosion hazard

SIL Allocation						
Consequences to People	**S**	S0 - No consequences	0	**SIL (People)**		-
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		-
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	-
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	-

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	Since overheating protection for H4006 is ensured by TAHH-466, TAHH-467 and TAHH-469, SIL Allocation for this function has not been performed

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C5500		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 132.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-511***	***#***	***17***
P&Id n.	I20784 Sh 37B	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-511	
Logic Solver	-	ESD
Final elements	C5500	activate trip of compressor

Scenario description	
Initiating events	Unexpected closure of HV-504
Consequences	Pressure build up on compressor discharge system (DP=49 barg) and possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 1000	1000		**Selected**	**a**

Notes		
S selection		
E selection		
F selection		
P selection		
W selection		
IPL	PIC-504 to open PV-505 (RRF = 10) PSV-503 (RRF = 100)	
Selected SIL		
Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	EW5000 NG line		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 135.4		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-535***	***#***	***18***
P&Id n.	I20784 Sh 37	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-535	
Logic Solver	-	ESD
Final elements	TV-530B	activate closure of TV-530B

Scenario description	
Initiating events	Unexpected opening of TV-530B
Consequences	During dryer heating mode, higher temperature of natural gas to downstream section (220°C instead of 10°C) due to by-pass of HW5000, with possible overheating (DT=65°C for EW5000) resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**a**

Notes	New SIF from HAZOP Recommendation 30. Add a high high temperature interlock initiated by TI-535 to close TV-530B
S selection	
E selection	
F selection	
P selection	
W selection	W1 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	Additional independent high temperature alarm considered implemented as per following action
Selected SIL	

Action	3	Provide an additional independent temperature transmitter on NG line upstream EW5000 including high temperature alarm

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	HW5000 outlet		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 137.5		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-532***	***#***	***19***
P&Id n.	I20784 Sh 36	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-532	
Logic Solver	-	ESD
Final elements	TV-530A	activate closure of TV-530A

Scenario description	
Initiating events	Loss of chilled water supply to HW5000
Consequences	During dryer heating mode, higher temperature of natural gas to downstream section (220°C instead of 10°C) with possible overheating (DT=65°C for EW5000) resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	W1 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	TAH535 and operator response
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	HW5503 outlet		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 137.9		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH***	***#***	***20***
P&Id n.	I20784 Sh 37B	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT downstream HW5503	
Logic Solver	-	ESD
Final elements	C5500	trip of compressor

Scenario description	
Initiating events	Loss of cooling water to HW5503
Consequences	Higher temperature of natural gas (estimated approximately 137°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	New SIF from HAZOP Recommendation 34. Add a high high temperature interlock downstream HW5503 to activate trip of compressor
S selection	
E selection	
F selection	
P selection	
W selection	W1 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	ST5501		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 140.4		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-501B***	***#***	***21***
P&Id n.	I20784 Sh 37A	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-501B	
Logic Solver	-	ESD
Final elements	HV-515	activate closure of HV-515

Scenario description	
Initiating events	Malfunction of LIC-501A not closing DV-501 on demand
Consequences	Natural gas at 4.9 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**2**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**2**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**2**

Notes	See HAZOP Recommendation N 35 Investigate additional safeguard to prevent overpressurization in S2011 in case of gas breakthrough from compressor separators (e.g. PSV routed to cold flare located downstream HV-515, additional PAHH on drain line to S2011 acting on additional on/off valve etc..)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	ST5502		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 140.5		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-502B***	***#***	***22***
P&Id n.	I20784 Sh 37A	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-502B	
Logic Solver	-	ESD
Final elements	HV-515	activate closure of HV-515

Scenario description	
Initiating events	Malfunction of LIC-502A not closing DV-502 on demand
Consequences	Natural gas at 15 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**2**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**2**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**2**

Notes	See HAZOP Reccomendation N 35 Investigate additional safeguard to prevent overpressurization in S2011 in case of gas breakthrough from compressor separators (e.g. PSV routed to cold flare located downstream HV-515, additional PAHH on drain line to S2011 acting on additional on/off valve etc..)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	ST5503		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 140.6		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LALL-503B***	***#***	***23***
P&Id n.	I20784 Sh 37B	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-503B	
Logic Solver	-	ESD
Final elements	HV-515	activate closure of HV-515

Scenario description	
Initiating events	Malfunction of LIC-503A not closing DV-503 on demand
Consequences	Natural gas at 43 barg routed to S2011 (DP=2 barg) with pressure build up, potential overpressurization resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**2**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**2**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**2**

Notes	See HAZOP Reccomendation N 35 Investigate additional safeguard to prevent overpressurization in S2011 in case of gas breakthrough from compressor separators (e.g. PSV routed to cold flare located downstream HV-515, additional PAHH on drain line to S2011 acting on additional on/off valve etc..)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S7003		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 144.4, 151.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-717***	***#***	***24***
P&Id n.	I20784 Sh 23	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-717	
Logic Solver	-	ESD
Final elements	HV-700	activate closure of HV-700

Scenario description	
Initiating events	1) Malfunction of PIC-715A closing PV-715 2) Malfunction of PIC-703 fully opening PV-703
Consequences	Pressure build up up to max 43 barg in LNG separator S7003 (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages inside the cold box with potential cold box overpressurization, mechanical damage and injuries to personnel (fire/explosion hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-705 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S7003
Session/Date	#2/17/04/23			***Parameter***	Level
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 144.5
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH-716*** ***#*** ***25a***
P&Id n.	I20784 Sh 23	rev.	0C		

Safety Instrumented Function Description		
Initiator	LT-716	
Logic Solver	-	ESD
Final elements	HV-700	activate closure of HV-700

Scenario description	
Initiating events	Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV1913A/B
Consequences	Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	TALL-915 activate closure HV-721 (not rated, RRF=10)
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	S7003		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 144.5		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH-716***	***#***	***25b***
P&Id n.	I20784 Sh 23	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT-716	
Logic Solver	-	ESD
Final elements	HV-700	activate closure of HV-700

Scenario description	
Initiating events	Malfunction of LIC-715A closing LV-715 or unexpected closure of HV-717 or HV1913A/B
Consequences	Level build up in LNG separator S7003 resulting in possible overfilling and LNG carry over to EW9000 with consequent vaporization resulting in pressure build up in EW9000 and associated piping (DP=16 barg) leading to potential overpressurization, mechanical damage and potential for LNG leakages with possible injuries to personnel (fire/explosion hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 1000	1000		**Selected**	**1**

Notes	Same actions activated by PAHH-717
	See HAZOP Recommendation 36 - PSV-914 shall be verified for LNG vaporization in EW9000
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSH-715A activate opening HV-715 to cold flare KO drum V16000 (RRF =10); PSV-914 considered verified for LNG vaporization in EW9000 as per HAZOP recommendation N 36 (RRF =100)
Selected SIL	Selected SIL 1 according to worksheet SIF#25a

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	V16000		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 147.3		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH***	***#***	***26***
P&Id n.	I20784 Sh 39A	rev.	0C				

Safety Instrumented Function Description		
Initiator	LT	
Logic Solver	-	ESD
Final elements	HV-700	activate closure of HV-700

Scenario description	
Initiating events	Unexpected opening of HV-711
Consequences	LNG routed to cold flare KO drum V16000 resulting in KO drum overfilling and possible liquid carry over to cold flare resulting in LNG outflow from flare tips with potential injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	New SIF from HAZOP Recommendation N 39: Add a high high level interlock on V16000 to activate closure of HV-700 (relevant set point to be defined to allow adequate residual volume preventing overfilling after HV-700 closure)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	Discrepancy alarm on HVs
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	TL19000 (Truck loading bay)		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 169.6, 170.1, 171.1, 175.4		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-1960A***	***#***	***27***
P&Id n.	I20784 Sh 34	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-1960A	
Logic Solver	-	ESD
Final elements	SY1950AA, HV-1952A	PAHH-1960A activate closure of on/off pneumatic valve on truck inlet by means of SY1950AA and closure HV-1952A

Scenario description	
Initiating events	1) Unexpected closure of HV-1957A, PV-1958A, HV1956A (when BOG is routed back to tank) or Unexpected closure of PV-1959A, HV-1958A (when BOG from road tanker is routed to BOG compressor) 2) Malfunction of FIC-1950A opening more than required FV1950A at the beginning of loading operation 3) Malfunction of WQ1900A leading to higher amount of LNG loaded on road tanker 4) Inadequate cooling of LNG line (HV-1950 not opening on demand including TSL-1951 malfunction)
Consequences	Pressure build up in road tanker up and potential overpressurization leading to mechanical damage, LNG leakage and possible fire/explosion hazard and injuries to personnel

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**2**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F2 - Frequent to permanent exposure	2	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**2**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**2**

Notes	Same actions initiated also by PAHH-1961A, not effective only in case of blocked outlet on gas return line inside road tanker
	See HAZOP recommendation N 45: Set point of PAHH-1960A and PAHH-1961A shall be defined taking into account lowest design pressure for road tankers (design pressure of road tankers to be checked by OGE, currently available value is 7 barg)
S selection	
E selection	
F selection	F2 selected considering continuous presence of operator/driver during transfer
P selection	
W selection	W2 selected taking into account operating factor for truck loading
IPL	Action 4 assumed as implemented providing RRF = 10
Selected SIL	

Action	4	Provide an independent function (additional pressure transmitter) to trip P19000 and to close HV-1902A in case of high pressure (set point lower than PAHH-1960A)

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	Truck loading station		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 182.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PALL-1960A***	***#***	***28***
P&Id n.	I20784 Sh 34	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-1960A	
Logic Solver	-	ESD
Final elements	P19000, HV-1952A, SY-1950AA	activate trip of pump P19000, close HV-1952A and SY-1950AA

Scenario description	
Initiating events	Hose failure
Consequences	Release of LNG on loading area with possible fire/explosion hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F2 - Frequent to permanent exposure	2	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	Same actions initiated also by PALL-1961A
S selection	
E selection	
F selection	F2 selected considering continuous presence of operator/driver during transfer
P selection	P1 selected considering event detectable
W selection	
IPL	
Selected SIL	

Action	5	Intervention of PALL-1961A shall also close HV-1957A and HV-1958A

Study	SIL Allocation			***Project***	LNG liquefaction plant			
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	EW9000 BOG line			
Session/Date	#2/17/04/23			***Parameter***	Temperature			
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low			
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 171.1, 173.4, 174.3			
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TALL-914***	***#***	***29***	
P&Id n.	I20784 Sh 38	rev.	0C					

Safety Instrumented Function Description		
Initiator	TT-914	
Logic Solver	-	ESD
Final elements	HV-1958A/B	activate closure HV-1958A/B

Scenario description	
Initiating events	1) Malfunction of WQ-1900A leading to higher amount of LNG loaded on road tanker 2) HV-1953A stuck in open position after hose drain 3) Loss of LP steam in EW9000 including malfunction of TIC-952 closing TV-952
Consequences	1) Possible overfilling of road tanker with consequent liquid carry over to BOG line back to heater EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment 2) During next loading operation, LNG partially routed to BOG line with consequent liquid carry over to heater EW9000 with possible embrittlement of downstream piping leading to mechanical damage and loss of containment 3) BOG routed to BOG compressor inlet line at -168°C instead of 20°C with possible embrittlement of piping resulting in mechanical and injuries to personnel (fire/explosion hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	Independent temperature transmitter with low temperature alarm as per following action
Selected SIL	

Action	6	Provide an additional independent temperature transmitter at EW9000 outlet (road tanker BOG line) with low temperature alarm

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	VT19000		
Session/Date	#2/17/04/23			***Parameter***	Level		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 179.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***LAHH-1900A***	***#***	***30***
P&Id n.	I20784 Sh 30	rev.	0C				

Safety Instrumented Function Description		
Initiator	LIT-1900A	
Logic Solver	-	ESD
Final elements	HV-1913A	activate closure of HV-1913A (after closure of HV-1913A all LNG production will be diverted to VT19001)

Scenario description	
Initiating events	Inadequate monitoring of tank level including LI-1900A or LI-1901A malfunction
Consequences	Level build up in VT19000 and consequent overfilling leading to blocked outlet condition for LNG separator bottom line resulting in level build up in S7003 (see no/less flow in node #11). Possible liquid carry over to EW9000.

SIL Allocation						
Consequences to People	**S**	S0 - No consequences	0	**SIL (People)**		-
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		-
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	-
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	-

Notes	Same consideration for LAHH1901A
	Scenario already protected by LAHH-716 (rated SIL1) on S7003
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C5500		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 135.8		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-510***	***#***	***31***
P&Id n.	I20784 Sh 37A	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-510	
Logic Solver	-	ESD
Final elements	C5500	activate trip of compressor C5500

Scenario description	
Initiating events	Malfunction of PIC-500/PIC-504 opening PV-505 when not required
Consequences	Pressure build up on C5500 suction (DP=10 barg) resulting in possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-501, PSV-530
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C9100		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 157.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-911***	***#***	***32***
P&Id n.	I20784 Sh 38B	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-911	
Logic Solver	-	ESD
Final elements	C9100	activate trip of compressor

Scenario description	
Initiating events	Unexpected closure of HV-904
Consequences	Pressure build up on compressor discharge system (DP=49 barg) and possible overpressurization leading to mechanical damage, loss of containment, potential for fire/explosion, injuries to personnel

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-903
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	EW9000 NG line (from tank)		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 160.1, 161.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TALL-913***	***#***	***33***
P&Id n.	I20784 Sh 38	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-913	
Logic Solver	-	ESD
Final elements	HV-939	activate closure of HV-939

Scenario description	
Initiating events	1) PV-1910A stuck in open position during compressor in operation (PV-1910B opened) 2) Loss of duty in EW9000 (loss of LP steam supply including malfunction of TIC-952)
Consequences	Lower temperature on downstream EW9000 coil and consequent lower temperature on downstream piping with possible embrittlement of piping leading to mechanical damage and loss of containment with possible fire/explosion hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	Same function is also initiated by TALL-953
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	Independent temperature transmitter with low temperature alarm as per following action
Selected SIL	

Action	7	Provide an additional independent temperature transmitter at EW9000 outlet (storage tank BOG line) with low temperature alarm

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	EW9000 NG line		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 148.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TALL-915***	***#***	***34***
P&Id n.	I20784 Sh 38	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-915	
Logic Solver	-	ESD
Final elements	HV-721	activate closure HV-721

Scenario description	
Initiating events	Loss of LP steam in EW9000 including malfunction of TIC-952 closing TV-952
Consequences	Natural gas routed to thermal oxidizer inlet line at -168°C instead of 20°C with possible embrittlement of piping resulting in mechanical and injuries to personnel (fire/explosion hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	W2 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	Independent temperature transmitter with low temperature alarm as per following action
Selected SIL	

Action	8	Provide an additional independent temperature transmitter at EW9000 outlet (NG line) with low temperature alarm

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	HW9103 downstream line		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 162.4		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH***	***#***	***35***
P&Id n.		rev.					

Safety Instrumented Function Description		
Initiator	TT	
Logic Solver	-	ESD
Final elements	C9100	trip of BOG compressor C9100

Scenario description	
Initiating events	Loss of cooling water to HW9103
Consequences	Higher temperature of BOG recovery gas (estimated approximately 175°C) on equipment and piping on third stage discharge downstream aftercooler (DT=65°C) resulting in mechanical damage and possible leak of natural gas with possible fire

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	New SIF from HAZOP Recommendation N 42 Add a high high temperature interlock downstream HW9103 to activate trip of BOG compressor C9100
S selection	
E selection	
F selection	
P selection	
W selection	W1 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C7500/7600		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 220.4, 223.1, 223.6		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PALL-750***	***#***	***36***
P&Id n.	I20784 Sh 26	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-750	
Logic Solver	-	ESD
Final elements	HV-710/712, UV-760	activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760)

Scenario description	
Initiating events	1) Compressor failure/stop (any cause) 2) Malfunction of PIC-740B opening PV-740B when not required 3) Unexpected opening of UV-763
Consequences	Lower suction pressure/flowrate for C7500/C7600 turbines boosters resulting in potential surge condition leading to turbines boosters damage and consequent extensive damage. Possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	P1 selected considering presence of Oxygen monitoring inside building to give alarm (inside horn and outside light)
W selection	
IPL	Anti surge control system opening UV-760
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	SC7001		
Session/Date	#2/17/04/23			***Parameter***	Pressure		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 231.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-722***	***#***	***37***
P&Id n.	I20784 Sh 23	rev.	0C				

Safety Instrumented Function Description		
Initiator	PT-722	
Logic Solver	-	ESD
Final elements	HV-700	activate closure of HV-700

Scenario description	
Initiating events	Malfunction of PIC-719 closing PV-719
Consequences	Pressure build up in SC7001 leading to potential overpressurization (DP=8 barg) with mechanical damage and consequent leakage of liquefied nitrogen inside cold box leading to vaporization and potential overpressurization of cold box with mechanical damage (injuries to personnel)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-718 sized including this scenario
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C7400		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 225.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-749***	***#***	***38***
P&Id n.	I20784 Sh 25	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-749	
Logic Solver	-	ESD
Final elements	C7400	activate trip of compressor

Scenario description	
Initiating events	Malfunction of TIC-747 or TIC-748 reducing speed of fan E7400/E7401 or air coolers E7400/E7401 failure
Consequences	Higher temperature of nitrogen sent to downstream sections (DT = 65°C) with possible mechanical damage of piping overtime leading to loss of containment resulting in possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)/possible injuries due to contact with hot product

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	P1 selected considering presence of Oxygen monitoring inside building to give alarm (inside horn and outside light)
W selection	
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	LNG to HX7000		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 225.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-708***	***#***	***39***
P&Id n.	I20784 Sh 22	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-708	
Logic Solver	-	ESD
Final elements	C7400	activate trip of compressor

Scenario description	
Initiating events	Malfunction of TIC-747 or TIC-748 reducing speed of fan E7400/E7401 or air coolers E7400/E7401 failure
Consequences	Higher temperature of stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating leading to possible leakages of pressurized nitrogen inside cold box with potential overpressurization and mechanical damage (injuries to personnel)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	Overpressure hatch provided on cold box
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	HPN to HX7000		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 225.3		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-709***	***#***	***40***
P&Id n.	I20784 Sh 22	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-709	
Logic Solver	-	ESD
Final elements	HV-710/712	activate closure of HV-710/712

Scenario description	
Initiating events	Malfunction of TIC-754 or TIC-764 reducing speed of fan E7500/E7600 or air coolers E7500/E7600 failure
Consequences	Higher temperature of stream routed to primary heat exchanger (DT=65°C) resulting in possible mechanical damage due to overheating leading to possible leakages of pressurized nitrogen inside cold box with potential overpressurization and mechanical damage (injuries to personnel)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	Overpressure hatch provided on cold box
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	H17000 upstream line		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 247.1		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TALL-1707***	***#***	***41***
P&Id n.	I20784 Sh 42	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-1707	
Logic Solver	-	ESD
Final elements	HV-1700	activate closure of HV-1700

Scenario description	
Initiating events	Higher LIN demand rate during maintenance (cold box defrosting)
Consequences	Lower temperature of nitrogen downstream vaporizer E17002A/B with possible damage of piping downstream TV-1702 and TV-1705 due to embrittlement with possible injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	During defrosting operation, continuous personnel presence is not espected
P selection	
W selection	
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	H17000 downstream line		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	Low		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 247.2		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TALL-1704***	***#***	***42***
P&Id n.	I20784 Sh 22	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-1704	
Logic Solver	-	ESD
Final elements	TV-1702 / TV-1705	activate closure of TV-1702 and TV-1705

Scenario description	
Initiating events	Failure of H17000 including TIC-1703 malfunction reducing heat input to H17000
Consequences	Lower temperature of nitrogen downstream heater H17000 with possible damage of piping downstream TV-1702 and TV-1705 due to embrittlement with possible injuries to personnel

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**a**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**a**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**a**

Notes	
S selection	
E selection	
F selection	
P selection	
W selection	Event expected only in emergency scenario (need for nitrogen back up) during winter time
IPL	
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant			
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	V16200			
Session/Date	#2/17/04/23			***Parameter***	Pressure			
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High			
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 183.4			
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***PAHH-1640***	***#***	***43***	
P&Id n.	I20784 Sh 70	rev.	0C					

Safety Instrumented Function Description		
Initiator	PT-1640	
Logic Solver	-	ESD
Final elements	HV-721, H16200/H16201, HV-1646	activate closure of HV-721 and HV-1646 and trip H16200/H16201

Scenario description	
Initiating events	Unexpected closure of HV-1645
Consequences	Pressure build up in V16200 due to vaporization of liquid and possible overpressurization resulting in possible mechanical damage leading to injuries to personnel/leakages and fire hazard

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 100	100		**Selected**	**1**

Notes	See HAZOP Recommendation N 51 PAHH-1640 shall also close HV-721 and trip H16200/H16201
	See HAZOP Recommendation N 50 PSV-914 shall be verified for blocked outlet condition on V16200
	See HAZOP Recommendation N 49 PAHH-1640 shall also close HV-1646 to segregate stripper condensate separator S2011 from heavy HC KO drum V16200
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	PSV-914 (considering implemented HAZOP recommendation N 50)
Selected SIL	

Action	9	Ensure adequate set point for PAHH-1640 to prevent overpressurization on upstream S2011 (DP=2 barg)

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C7400		
Session/Date	#2/17/04/23			***Parameter***			
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***			
Team	Refer to SIL Attendance List			***HAZOP Reference***	causes 220.5, 220.7, 220.9, 223.5		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***USPM***	***#***	***44***
P&Id n.		rev.					

Safety Instrumented Function Description		
Initiator	PT/TT	antisurge protection
Logic Solver	-	ESD
Final elements	C7400	trip of compressor

Scenario description	
Initiating events	1) Malfunction of compressor capacity control system leading to closure of compressor IGV 2) Unexpected closure of UV-761 3) Unexpected closure of HV-712 or HV-710 (quick closing valves)
Consequences	Potential surge condition leading to compressor damage and consequent extensive damage (major economical losses including operation disruption)/possible impact on personnel in case of nitrogen leakage into the building (asphyxiation hazard)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P1 - Hazardous situation can be avoided	1			
Demand rate	**W**	W3 - Demand rate between 1 D and 10 D per year	3	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL = 10	10		**Selected**	**1**

Notes	
S selection	
E selection	
F selection	
P selection	P1 selected considering presence of Oxygen monitoring inside building to give alarm (inside horn and outside light)
W selection	
IPL	Anti surge control system to open compressor by-pass valve (PCV)
Selected SIL	

Action		

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	WB41/WB42		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 7.2		
C&Ed n.	520REZH433004000SRI00101	rev.	0E	***SIF***	***TAHH***	***#***	***45***
P&Id n.		rev.					

Safety Instrumented Function Description		
Initiator	TT	independent temperature transmitter at WB41/WB42 outlet
Logic Solver	-	ESD
Final elements	WB41/WB42	to trip heater WB41/WB42

Scenario description	
Initiating events	Higher heat input from heater W-B41 due to failure of relevant temperature control system (TT-B40621)
Consequences	Increase of natural gas temperature and potential overheating of downstream piping (DT=80°C) with potential mechanical damage and loss of containment (possible fire/explosion)

SIL Allocation						
Consequences to People	**S**	S3 - Severe injuries/single fatality	3	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W1 - Demand rate less than 0,1 D per year	1	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	Function required by HAZOP recommendation N 4 - Ensure provision for internal independent high high temperature interlock provided for heater W-B41 to protect heater itself and downstream piping from overheating scenario
S selection	
E selection	
F selection	
P selection	
W selection	W1 selected since scenario with Severity S3 is expected only in case of ignition of gas leakage
IPL	
Selected SIL	

Action	10	Investigate availability of other IPL to prevent piping overheating downstream WB41/WB42

Study	SIL Allocation			***Project***	LNG liquefaction plant		
Client	SIAD / OGE / BIOPLUS GmbH			***Item***	C7400		
Session/Date	#2/17/04/23			***Parameter***	Temperature		
SIL Facilitator/Scribe	Fabrizio Bucci/Debora D'Ostilio			***Deviation***	High		
Team	Refer to SIL Attendance List			***HAZOP Reference***	cause 225.3		
C&Ed n.	140REZH690010001PFS00101	rev.	0C	***SIF***	***TAHH-752***	***#***	***46***
P&Id n.	I20784 Sh 26	rev.	0C				

Safety Instrumented Function Description		
Initiator	TT-752	
Logic Solver	-	ESD
Final elements	HV-710/712	activate closure of HV-710/712

Scenario description	
Initiating events	Malfunction of TIC-754 reducing speed of fan E7500 or air coolers E7500 failure
Consequences	Higher temperature of stream routed to downstream systems leading to possible overheating on downstream sections leading to loss of containment resulting in possible injuries due to contact with hot product (piping outside building)

SIL Allocation						
Consequences to People	**S**	S2 - Injuries with reversible effects	2	**SIL (People)**		**1**
Consequences to Environment	**E**	E0 - No impact	0			
Occupancy	**F**	F1 - Rare to more frequent exposure. Occupancy less than 0,1	1	**SIL (Environmental)**		**-**
Probability of avoiding the hazardous situation	**P**	P2 - Hazardous situation cannot be avoided	2			
Demand rate	**W**	W2 - Demand rate between 0,1 D and 1 D per year	2	**SIL**	**Calculated (max)**	**1**
Independent Protection Layer	**IPL**	IPL Not available	0		**Selected**	**1**

Notes	This allocation is also representative for TAHH-762
	See HAZOP Recommendation N 63 (Relocate TAHH-752 downstream E7500 and TAHH-762 downstream E7600)
S selection	
E selection	
F selection	
P selection	
W selection	
IPL	
Selected SIL	By implementing HAZOP Recommendation N 64 (Consider to review DT of piping dowstream aircoolers E7400/7401/7500/7600 taking into account air cooler failure scenario) this SIF will not be rated

Action		

ATTACHMENT 6

SIFs List

SIF List											
Study	SIL Allocation										
Client	SIAD / BIOPLUS GmbH / OGE										
Project	LNG liquefaction plant, Renzenhof (Germany)										

n.	SIF	Item	Deviation	Scenario	Category	Initiator TAG	Logic solver TAG	Final Elements	Actions	SIL rated	Notes
1	**PDAHH-105**	S1001	Flow Misdirect	Natural gas sent to cold flare	E	PDT-105	-	HV-105, HV-106	activate closure of HV-105, HV-106 in case of high high DP	a	
2	**LALL-144**	TW1002	Level Low	Gas breakthrough to flash vessel and overpressurization of S1003	S	LSLL-144	-	LV-146	activate closure of LV-146	a	
3	**PAHH-601**	MDL6000	Pressure High	Overpressurization of feed gas module	S	PT-601	-	HV-600	activate closure of HV-600	a	
4	**PAHH-172**	S1003	Pressure High	Overpressurization of flash vessel S1003	S	PSHH-172	-	LV-146	activate closure of LV-146	1	
5	**LALL-209**	TW2008	Level Low	Damage of P-2005A/B and NG leakage due to backflow from TW1002	S	LT-209	-	P-2005A/B	activate trip of pump P-2005A/B	a	
6	**LALL-164**	S1003	Level Low	breakthrough to stripping column TW2008 and overpressurization	S	LSLL-164	-	LV-151	activate closure of LV-151	1	
7	**LALL-472**	ST4001	Level Low	breakthrough to flash vessel S1003 and overpressurization	S	LSLL-472	-	LV-413	activate closure of LV-413	a	
8	**PAHH-282**	S2011	Pressure High	ovepressurization of TW2008 and S2011	S	PT-282	-	FV-204, LV-151	activate closure of FV-204 and closure of LV-151	-	From HAZOP Recommendation N 14: Add closure of LV-151 among actions initiated by PAHH-282
9	**LAHH-279**	S2011	Level More	ovepressurization of TW2008 and S2011	S	LSHH-279	-	FV-204, LV-151	activate closure of FV-204 and closure of LV-151	a	From HAZOP Recommendation 16: Add closure of LV-151 among actions initiated by LAHH-279
10	**PAHH**	TW2008	Pressure High	ovepressurization of TW2008	S	PT	-	HV-138	activate closure HV-138	1	New SIF from HAZOP Recommendation N 16: Add dedicated interlock to shut down HV-138 in case of back flow due to both P2005A/B not running (e.g. high high pressure detected on common pump suction line)
11	**TAHH-211**	H2001	Temperature High	ovepressurization of H2001	S	TT-211	-	H2001	activate trip of heater H2001	1	
12	**PAHH-289**	F2001/2/3	Pressure High	overpressurization of F2001, F2002 and F2003	S	PT-289	-	P-2005A/B	activate trip of P-2005A/B	1	
13	**LAHH-305**	V3004	Level High	overfilling of V3004	S, E	LT-305	-	P3002	activate trip of pump P3002 (used for equipment drainage)	-	

SIF List	
Study	SIL Allocation
Client	SIAD / BIOPLUS GmbH / OGE
Project	LNG liquefaction plant, Renzenhof (Germany)

n.	SIF	Item	Deviation	Scenario	Category	Initiator TAG	Logic solver TAG	Final Elements	Actions	SIL rated	Notes
14	**PAHH-528**	MDL5000	Pressure High	NG regeneration module overpressurization	S	PT-528	-	PV-527	activate closure of PV-527 (for depressurization circuit)	a	
15	**TAHH-466**	H4006	Temperature High	overheating of H4006	S	TT-466	-	H4006	activate trip of heater H4006	1	Same allocation applies to TAHH-469 and TAHH-467
16	**PDALL-481**	H4006	Differential pressure Low	overheating of H4006	S	PDT-481	-	H4006	activate trip of heater H4006	-	Since overheating protection for H4006 is ensured by TAHH-466, TAHH-467 and TAHH-469, SIL Allocation for this function has not been performed
17	**PAHH-511**	C5500	Pressure High	compressor discharge overpressurization	S	PT-511	-	C5500	activate trip of compressor	a	
18	**TAHH-535**	EW5000 NG line	Temperature High	overheating of natural gas to EW5000 downstream	S	TT-535	-	TV-530B	activate closure of TV-530B	a	
19	**TAHH-532**	HW5000 outlet	Temperature High	overheating of natural gas to EW5000 downstream	S	TT-532	-	TV-530A	activate closure of TV-530A	a	
20	**TAHH**	HW5503 outlet	Temperature High	overheating of natural gas on equipment and piping on third stage discharge	S	TT downstream HW5503	-	C5500	trip of compressor	1	New SIF from HAZOP Recommendation 34. Add a high high temperature interlock downstream HW5503 to activate trip of compressor
21	**LALL-501B**	ST5501	Level Low	overpressurization of S2011	S	LT-501B	-	HV-515	activate closure of HV-515	2	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1

SIF List		
Study	SIL Allocation	
Client	SIAD / BIOPLUS GmbH / OGE	
Project	LNG liquefaction plant, Renzenhof (Germany)	

n.	SIF	Item	Deviation	Scenario	Category	Initiator TAG	Logic solver TAG	Final Elements	Actions	SIL rated	Notes
22	**LALL-502B**	ST5502	Level Low	overpressurization of S2011	S	LT-502B	-	HV-515	activate closure of HV-515	2	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1
23	**LALL-503B**	ST5503	Level Low	overpressurization of S2011	S	LT-503B	-	HV-515	activate closure of HV-515	2	Proposed solution for implementation of HAZOP Recommendation N 35 is to add an additional ON/OFF valve on the condensate connection line at the inlet of separator S2011 (CD-201-1/2"-A29-I) initiated by high high pressure detected by PI-282. By implementing this solution SIL can be derated from 2 to 1
24	**PAHH-717**	S7003	Pressure High	overpressure of S7003	S	PT-717	-	HV-700	activate closure of HV-700	1	
25a	**LAHH-716**	S7003	Level High	overfilling of S7003 (embrittlement of downstream piping)	S	LT-716	-	HV-700	activate closure of HV-700	1	
25b				overfilling of S7003 (pressure build up in S7003 / EW9000)	S						
26	**LAHH on V16000**	V16000	Level High	overfilling of V16000	S	LT	-	HV-700	activate closure of HV-700	1	New SIF from HAZOP Recommendation N 39: Add a high high level interlock on V16000 to activate closure of HV-700 (relevant set point to be defined to allow adequate residual volume preventing overfilling after HV-700 closure)
27	**PAHH-1960A**	TL19000 (Truck loading bay)	Pressure High	overpressure in road tanker	S	PT-1960A	-	SY1950AA, HV-1952A	PAHH-1960A activate closure of on/off pneumatic valve on truck inlet by means of SY1950AA and closure HV-1952A	2	Same actions initiated also by PAHH-1961A, not effective only in case of blocked outlet on gas return line inside road tanker
28	**PALL-1960A**	Truck loading station	Pressure	fire/explosion hazard in loading area	S	PT-1960A	-	P19000, HV-1952A, SY-1950AA	activate trip of pump P19000, close HV-1952A and SY-1950AA	1	

SIF List

Study	SIL Allocation		
Client	SIAD / BIOPLUS GmbH / OGE		
Project	LNG liquefaction plant, Renzenhof (Germany)		

n.	SIF	Item	Deviation	Scenario	Category	Initiator TAG	Logic solver TAG	Final Elements	Actions	SIL rated	Notes
29	**TALL-914**	EW9000 BOG line	Temperature Low	overheating of BOG from EW9000	S	TT-914	-	HV-1958A/B	activate closure HV-1958A/B	1	
30	**LAHH-1900A**	VT19000	Level High	overfilling of VT19000	S	LIT-1900A	-	HV-1913A	activate closure of HV-1913A (after closure of HV-1913A all LNG production will be diverted to VT19001)	-	Same allocation applies to LAHH1901A
31	**PAHH-510**	C5500	Pressure High	Pressure build up on C5500 suction	S	PT-510	-	C5500	activate trip of compressor C5500	a	
32	**PAHH-911**	C9100	Pressure High	Pressure build up on compressor discharge	S	PT-911	-	C9100	activate trip of compressor	1	
33	**TALL-913**	EW9000 NG line (from tank)	Temperature Low	overheating of NG from EW9000	S	TT-913	-	HV-939	activate closure of HV-939	1	Same allocation applies to TALL-953
34	**TALL-915**	EW9000 NG line	Temperature Low	low low temperature on thermal oxidizer	S	TT-915	-	HV-721	activate closure HV-721	1	
35	**TAHH**	HW9103 downstream line	Temperature High	overheating of HW9103 downstream line	S	TT	-	C9100	trip of BOG compressor C9100	1	New SIF from HAZOP Recommendation N 42 Add a high high temperature interlock downstream HW9103 to activate trip of BOG compressor C9100
36	**PALL-750**	C7500/7600	Pressure Low	turbines boosters damage	S	PT-750	-	HV-710/712, UV-760	activate shut-down of turbines T7500/T7600 and relevant boosters (through closure of HV-710/712 and opening UV-760)	1	
37	**PAHH-722**	SC7001	Pressure High	overpressurization of SC7001	S	PT-722	-	HV-700	activate closure of HV-700	1	
38	**TAHH-749**	C7400	Temperature High	overheating of piping downstream E7400/E7401	S	TT-749	-	C7400	activate trip of compressor	1	
39	**TAHH-708**	LNG to HX7000	Temperature High	overheating of stream routed to primary heat exchanger	S	TT-708	-	C7400	activate trip of compressor	1	
40	**TAHH-709**	HPN to HX7000	Temperature High	overheating of stream routed to primary heat exchanger	S	TT-709	-	HV-710/712	activate closure of HV-710/712	1	
41	**TALL-1707**	H17000 upstream line	Temperature Low	lower temperature of nitrogen downstream vaporizer E17002A/B	S	TT-1707	-	HV-1700	activate closure of HV-1700	a	
42	**TALL-1704**	H17000 downstream line	Temperature Low	lower temperature of nitrogen downstream heater H17000	S	TT-1704	-	TV-1702 / TV-1705	activate closure of TV-1702 and TV-1705	a	
43	**PAHH-1640**	V16200	Pressure High	V16200 mechanical damage	S	PT-1640	-	HV-721, H16200/H16201, HV-1646	activate closure of HV-721 and HV-1646 and trip H16200/H16201	1	New actions initiated by SIF PAHH-1640 from HAZOP Recommendation N 51
44	**USPM**	C7400	- -	compressor C7400 surge condition	S	PT/TT	-	C7400	trip of compressor	1	

SIF List											
Study	SIL Allocation										
Client	SIAD / BIOPLUS GmbH / OGE										
Project	LNG liquefaction plant, Renzenhof (Germany)										

n.	SIF	Item	Deviation	Scenario	Category	Initiator TAG	Logic solver TAG	Final Elements	Actions	SIL rated	Notes
45	**TAHH**	WB41/WB42	Temperature High	overheating of WB41/42 downstream piping	S	TT	-	WB41/WB42	to trip heater WB41/WB42	1	Function required by HAZOP recommendation N 4 - Ensure provision for internal independent high high temperature interlock provided for heater W-B41 to protect heater itself and downstream piping from overheating scenario
46	**TAHH-752**	TAHH-752	Temperature High	overheating on C7400 downstream sections	S	TT-752	-	HV-710/712	activate closure of HV-710/712	1	Same allocation applies to TAHH-762

ATTACHMENT 7

Reference HAZOP/SIL Procedures

ICARO

GUIDE LINES

HAZard and OPerability study (HAZOP)

PROPOSED	CHECKED	APPROVED	REV.	DATE	DESCRIPTION
F.Bucci	N.Manning	B.Frattini	04	31/01/2018	Updated
F.Bucci	N.Manning	M.G.Ruffi	03	06/07/2017	Updated
F.Bucci	N.Manning	M.G.Ruffi	02	10/11/2014	Updated
F.Bucci	N.Manning	M.G.Ruffi	01	20/02/2014	Updated
F.Bucci	N.Manning	M.G.Ruffi	00	23/08/2013	New edition

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INDEX

1. SCOPE

This procedure defines modalities and methodologies to be followed in developing the Hazard and Operability - HAZOP - study.

2. REFERENCES (LATEST EDITION)

- IEC-61882 “Hazard and operability studies (HAZOP studies) – Application guide, 2016.
- "HAZOP and multistage hazard study", Institution of Chemical Engineers, 1999.
- "Guidelines for Hazard Evaluation Procedures", 2nd Edition, CCPS and AIChE, 1992.
- "A Guide to Hazard and Operability Studies", Chemical Industries Association, 1990.

3. DEFINITIONS AND ACRONYMS

3.1 DEFINITIONS

CHARACTERISTIC Qualitative or quantitative property of an element (e.g. pressure, temperature, etc.), also identified as PARAMETER.

DESIGN INTENT Describes the designer’s desired or specific range of behaviour for elements and characteristics (operating conditions); also identified as “INTENTION”.

PARAMETERS The team generates possible deviations applying guidewords to various process parameters such as 'Flow', 'Level' and 'Pressure'. The selection of parameters is an important task for each team to devise for each individual system.

GUIDEWORDS Simple words which are used to qualify each intention in order to guide and stimulate the creative thinking process and discover deviations.

DEVIATION Departure from design intent. The variations from the intention are systematically identified by applying the "guidewords”

CAUSE Reason the occurrence of deviation. Once a deviation can be shown to have a conceivable or realistic cause, then it becomes meaningful. Only single jeopardy together with all relevant effects shall be considered during HAZOP. Deviation is meaningful only if it is physically possible.

CONSEQUENCES Results of the deviations.

HAZARD Consequence which have the potential to cause damage, injury or loss

SAFEGUARDS Protection, detection and indication mechanisms for the deviation and relevant consequences, which may be included within the selected part or form a portion of the design intentions of other parts

RECOMMENDATION Additional safety measure identified by process team, intended to reduce the risk connected to a specific deviation (also identified as “ACTION”).

3.2 ACRONYMS

ALARP	As Low As Reasonably Practicable
EPC	Engineering, Procurement and Construction
ESD	Emergency Shutdown
FEED	Front End Engineering Design
FTA	Fault Tree Analysis
HAZOP	Hazard and Operability Analysis
HSE	Health, Safety & Environment
IPL	Independent Protection Layer
LOPA	Layer Of Protection analysis
MOC	Management of Change
PFD	Process Flow Diagram
P&ID	Piping and Instrumentation Diagram
PSV	Pressure Safety Valve
QRA	Quantitative Risk Analysis
SIL	Safety integrity level
UFD	Utility Flow Diagram

4. CONTENTS

4.1 HAZOP PURPOSE AND GENERAL DESCRIPTION

A HAZOP study (also named “HAZOP review” hereinafter) is a systematic approach for identifying process hazards and operability problems of process systems and it is conducted by a multi-disciplinary team of individuals led by a Chairperson knowledgeable and experienced with the HAZOP technique.

The HAZOP study covers all the process lines and equipment that are part of, or may be affected by system/unit/plant involved in the study itself. This may include existing upstream and downstream facilities that may be affected by the process under review. Both existing system and projects can be processes by HAZOP review.

Key aspect of the HAZOP study shall be to assess if deviations from the design intention could occur and, if so, whether such deviations are likely to be hazardous or not.

The HAZOP study is primarily focused on the identification of major hazards capable to produce significant damages on people, environment and equipment. The Chairperson shall lead the team through the review focusing the attention on major aspects.

During the review attention will be also paid to environmental issues and plant operation (e.g. production quality; loss of production, etc.), even if with minor emphasis than safety.

Consequences that will be recognized secondary by the whole team will not be further investigated.

A set of guidewords is used by the team to ensure the thoroughness and structured approach of the Study. The guidewords are combined with process parameters to develop deviations.

The technique is based on the premise that a hazard will not occur if the process does not deviate from the design intent. The team determines if the deviation could realistically occur and, if so, makes an assessment on whether the consequences constitute a hazard or an operability problem. The team then evaluates if safeguards, intended as hardware or procedures, are adequate considering the causes and consequences of the deviation. If necessary, the team raises recommendation in order to enhance the design and mitigate possible risks. It is to highlight that:

- HAZOP is NOT a design check (it shall not provide design alternatives), nor an optimization study;
- HAZOP is NOT a tool addressed to find (detailed) solutions. The purpose is to highlight problems; relevant solutions may be proposed but will not be finalized during the session (shall be discussed in a separate session).

4.2 METHODOLOGY

4.2.1 Review workflow

The process/utility unit under analysis is divided into a set of sub units, composed by equipment, instrumentation and connecting lines. Each of these sub-units is named "node" and is characterized by specific process conditions.

The technique applies several guide words in order to identify the possible deviations from the process intents.

The analysis is performed in a systematic way, applying the following steps:

1. Identification of nodes;
2. Selection of node to be analysed;
3. Definition of the relevant design intent;
4. Application of a guideword;
5. Identification of relevant deviation;
6. Analysis of the possible causes, consequences, available protective measures and, If necessary, identification of specific recommendations with the aim of risk mitigation;
7. Identification of other deviations connected to the guide word and development of step 6;
8. Application of another guide word and development of steps 5 and 6;
9. Selection of another node and development of steps 3, 4, 5 and 6.

The above listed main steps of HAZOP review are summarized in the following scheme.

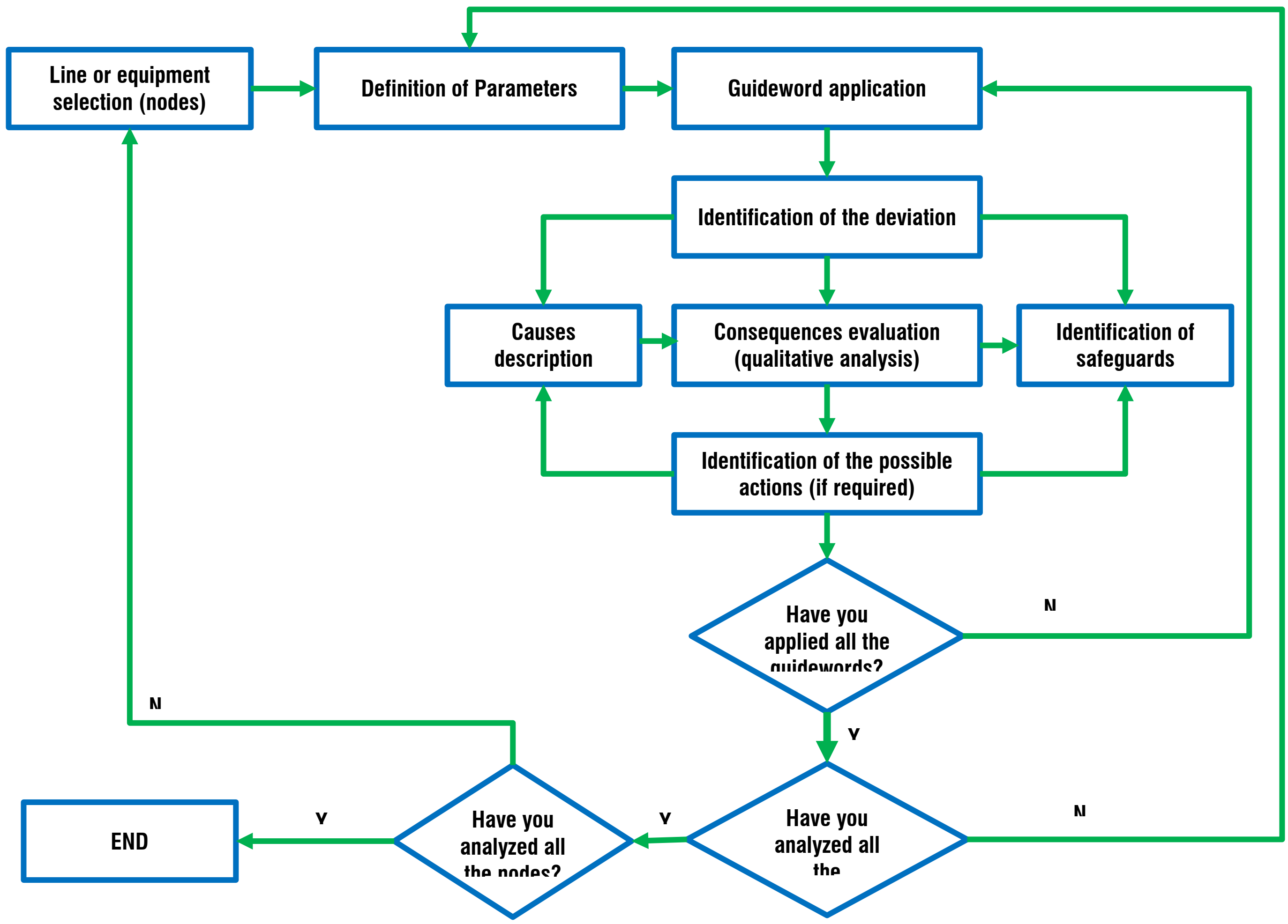


Figure 1 – HAZOP Workflow

Procedure is followed systematically until all P&IDs are analysed.

4.2.2 Nodes Identification

A node is a manageable segment of system which has distinct design intent.

The node, typically comprise one major equipment (vessels, etc.), associated minor equipment (pumps, valves, etc.), instrumentation, and other ancillary equipment. Normally, the selection of node should follow the process flow and starts at an isolation point. Node size shall be properly defined taking into account that very small nodes, such as a single process line, often lead to longer study times as each guide word combination should be recorded more times, but, on the other hand large nodes, such as multiple process lines and equipment items, confuse the application of the guidewords and if not properly managed, could lead to overlooking hazards.

The following criteria should be considered in selecting the appropriate transition to the next node:

- Change in design intent;
- Change in state (e.g., from liquid to vapour);
- Major pieces of equipment;
- Position of isolation device.

For discontinuous / batch processes, a node can be represented by a single step/sequence (defined in terms of time and operating conditions). Some nodes can involve, in different steps, the same equipment/lines.

For example, a CSTR reactor is a single equipment, but can be operated in different steps (e.g. chemicals and solvent injection, reaction, crystallization, solvent distillation, etc.

A tank farm can be considered as a "hybrid" system, since some system can be used for both dedicated and multiple operations, thus it is suggested to use a different approach in nodes identification, or rather, "by operation" (e.g. gasoline discharge from ship, tank, gasoil transfer from tank to tank, gantry bottom loading for road tanker, etc.).

4.2.3 Reference Parameters and Guidewords

4.2.3.1 Main parameters and guidewords

Main reference parameters are listed below:

- Flow;
- Level;
- Temperature;
- Pressure;
- Composition.

Additional parameter may be added case by case taking into account the characteristics of the process to be reviewed by HAZOP (e.g. pH, sequence, viscosity, amount, etc.). Additional parameter, if required, shall be defined and agreed by the team before the starting of the session.

The role of the guide word is to stimulate imaginative thinking, to focus the study and elicit ideas and discussion, thereby maximizing the chances of study completeness. Basic guidewords and their meanings are given in following table.

GUIDEWORDS	MEANING
NO or NOT	Complete negation of the design intent
MORE	Quantitative increase
LESS	Quantitative decrease
AS WELL AS	Qualitative modification / increase
PART OF	Qualitative modification / decrease
REVERSE	Logical opposite to the design intent
OTHER THAN	Complete substitution

Table 1 – Basic HAZOP Guidewords

Additional guidewords may be added case by case taking into account the characteristics of the process to be reviewed by HAZOP. If required, additional guidewords shall be defined and agreed by the team before the starting of the session.

The basic set of combination of parameters and relevant guidewords to be applied is reported on the following table.

PARAMETER	RELEVANT GUIDEWORDS			
Flow	No / Less	More	Reverse	Other than (misdirected)
Temperature	More	Less		
Pressure	More	Less/Vacuum		

Level	More	Less/No		
Composition	Other than			
Other than	Lack of utilities	Start/up - Shutdown	Corrosion / erosion	Other

Table 2 – Combination of Basic Parameters and relevant Guidewords

4.2.3.2 Specific parameters and guidewords for discontinuous / batch process

Proper parameter and guidewords shall be selected in case of discontinuous mode of operation either for automatic system or manned operations ("procedural HAZOP").

In such cases, the following main parameter can be used in addition or to replace to the ones used for continuous processes:

- Amount;
- Sequence / Action;
- (clock) Time;
- Mixing;
- Reaction.

Supplementary guidewords are listed in the following table.

GUIDEWORDS	MEANING
TOO EARLY	The order of sequence has been respected, but not the execution time. The operation is carried out too early
TOO LATE	The order of sequence has been respected, but not the execution time. The operation is carried out too late
TOO FAST	The duration of the operation/sequence is shorter than what is normally planned
TOO SLOW	The duration of the operation/sequence is longer than what is normally planned
BEFORE	The order of sequence has not been respected
AFTER	The order of sequence has not been respected

Table 3 – Supplementary HAZOP Guidewords

An example of combination of additional parameter and relevant guidewords to be applied for discontinuous process is reported on the following table.

PARAMETER	RELEVANT GUIDEWORDS						
AMOUNT	No/less	More					
SEQUENCE / ACTION	Too early	Too late	Too fast	Too slow	Before	After	Other than
TIME	Less	More					
MIXING	No/less	More					
REACTION	No/less	More	Other than				

Table 4 – Combination of Additional Parameters and relevant Guidewords

4.2.4 Description and Design intent definition

An adequate representation of the system to be investigated is a mandatory initial step on HAZOP review. Process characteristics, control philosophy, safeguarding philosophy shall be properly identified and described, as well as the reference design intent. In particular, an overall representation of the system shall be performed and detailed description of single nodes shall be described is required.

4.2.5 Basic assumptions

The following assumptions are adopted.

- Qualitative assessment of consequences does not take into account the availability and the effectiveness of relevant safeguard, unless the system is inherently safe.
- It is assumed that two or more concurrent failures of the same system / equipment will not occur, unless there is a common mode failure.
- When identical systems operate in parallel, study was done on one and the observations and findings are applicable to others.
- Only alarms and shutdown functions fully independent from control systems are considered as safeguards. In some cases, where highlighted consequences are associated only to operational problems also the presence of indicators (to DCS or in field) are considered as potential safeguards.
- Manual intervention is considered as a safeguard only if activated by dedicated independent alarms of the specific deviation, provided sufficient time and means are available for the operator to take actions and to bring the process to a safe state (at least 15-20 minutes). However, minimization of unnecessary alarms is followed as a general philosophy.
- The sentence: “Failure open (or failure close) of PIC (TIC, LIC, FIC, etc.)” implies the failure of any element of the control loop (sensor/transmitter, controller, transducer, control valve) that leads to a valve position which is different from the position required by design intention.
- In case of blinded line, the deviation "misdirect flow" is not analysed, either in case of misoperation and valve passing (internal leakage).

Other ground rules and assumption shall be defined case by case at the beginning of the study, taking into account client’s procedure, national regulations, international standards adopted and project basis.

4.2.6 Recording of HAZOP review’s outcomes

4.2.6.1 General aspects

HAZOP meeting will be recorded in “full recording” mode, to take evidence that all parameters and relevant guidewords have been processed for each node. Phrases such as “not applicable” or “no causes identified” will be applied in case parameter / guidewords are not relevant to the node.

If a deviation may occur and relevant consequences do not affect safety or environment, the expected scenario shall be, however, properly described (e.g.: loss of production, operational upset, product off-spec, etc.).

Recording will be performed by means of proper tool, such as PHA-works software by Primatech, or by other formats. HAZOP worksheet is included in **Attachment 1**.

Proper and detailed recording of cause, consequences and safeguards is also useful for possible further activities connected to HAZOP (e.g. LOPA, SIL Classification, FTA, QRA, etc.).

4.2.6.2 Causes

Process Causes shall be properly described by identifying the involved equipment/machine/instrument and the relevant unexpected mode of failure or what kind of human error has been performed. Nevertheless, it is not necessary to go too much in detail; for example, if a cause is related to a pump failure it is sufficient to write “pump failure” including the relevant tag (“P-1 failure” or “P-1 fails to start when required”); it is to avoid to identify all the possible mode of failure of the pump (electrical failure, gearbox failure, shaft or coupling mechanical damage, etc.). The same for a control loop failure; the general statement involves the whole control loop (and not the failure of each single element included in the loop itself), including the proper description of the failure mode. (e.g. "malfunction of FIC-001 that closes the relevant control valve FV-001").

Cause can be grouped in the following four main categories:

- Instrumentation failure (control loop failures, spurious intervention of shut-down valves, etc.);
- Machinery failure (pumps, compressor, mixers, etc.);
- Human errors (inadvertent closure of opening of manual valve, improper input of set-point, etc.);
- Causes external to the system (e.g. general black-out, loss of supply from upstream units, etc.).

It is worthy to highlight that:

- it is assumed that two or more concurrent failures of the same system / equipment ("double jeopardy") will not occur, unless there is a common mode failure (e.g. general power failure);
- a single cause of a deviation may lead to multiple consequences.

In order to have a clear approach to define all the possible hazardous scenario and, at the same time, to ensure that all the available safeguards are listed, the best solution is to adopt the following rule:

- Causes are identified within the node under investigation only (except for "external causes"); the relevant consequences can be in the node itself or everywhere else but will be recorded in the node where the deviation is generated.

Some exceptions can be applied in the following cases:

- Nodes at interface with other system not included in scope of work for the analysis;
- HAZOP on revamped unit (analysis on modified / new system only).

4.2.6.3 Consequences

Following main rules shall be followed during evaluation of the consequences associated to each cause of deviation:

- assessment of consequences is performed by a qualitative approach;
- availability and effectiveness of safeguards in place are not taken into account.

Different consequences can be caused by the same initiating cause (e.g. inadvertent closure of a manual valve on the discharge on the pump may lead to: pressure increase in the discharge, loss of feed to the next system, level increase on upstream equipment, damage to the pump due to overheating, etc.

Each one of them shall be properly recorded, taking into account the target of the study defined at the beginning.

As already mentioned in the previous paragraph relevant to causes, each cause is identified within the node under investigation but the relevant consequence(s) shall be investigated up to the end point (either the nose itself or different nodes). By using this approach will be possible to list the complete set of safeguards available

Each consequence scenario and relevant dynamics shall be properly described. If overpressurization may occur, the simple sentence "Possible overpressurization of V-1" is not sufficient to proper understand which would be the impact level, even though such evaluation is carried out in a qualitative manner only. The mentioned scenario shall be described as follows: *"pressure increase in V-1 (dP = 3,5 barg) leading to possible overpressurization up to 8 barg, resulting in mechanical damage an loss of containment of flammable gas, with potential for fire/explosion"*.

When a system is inherently safe, it has to be considered during consequences evaluation. Taking into account the previous example, if the dP of V-1 was 9 bar, the consequences of pressure increase shall be as follow: *"pressure increase in V-1 (dP = 9 barg). No impact on mechanical integrity is expected since the max pressure that can be reached is 8 barg"*.

It is suggested to avoid cross links between deviations, to have a clear and faster recording. If we are investigating a no/less flow deviation on a pump discharge, one of the relevant consequences is the pressure build-up. Assuming that in the list of parameters flow came earlier than pressure, this scenario can be directly analysed up to the end point on no/less flow deviation, instead of writing a reference such “see pressure more” in flow deviations. When, later on, pressure deviation will be discussed, a brief reference to flow will be done for the above mentioned scenario, with no further investigations.

Some general criteria for qualitative assessment of consequences are reported on **Attachment 2**.

An additional column can be added to allocate each consequence scenario in the proper category simply using a letter for a better understating of the category of the expected impact (e.g.: S = safety, scenario that can affect personnel, E = environment; scenario that can lead to environmental pollution, F = financial or O = operational or A = asset for scenario having economic impact due to loss of production, loss of equipment, upsets, need for maintenance and relative repair cost).

4.2.6.4 Safeguards

Safeguards shall be listed according to the sequence of intervention related to progressive layer of protection philosophy (e.g. alarm and human response, interlock, mechanical devices, etc.) and properly described (e.g. for interlocks, initiators, logic solver and final element shall be mentioned).

Proper and effective safeguards shall be listed for each single consequences scenario, taking into account that the following requirements shall be met:

- independency from the cause of the deviation and from other previously mentioned safeguards (e.g., an alarm associated to a control loop is not considered effective if the deviation is cause by a malfunction of the control loop itself);
- effectiveness in preventing the deviation or the relevant consequences (e.g. alarms are effective only if operator response is allowed, including adequate time to evaluate and react, proper action can be taken and in front of adequate training, adequacy of PSVs shall be verified for each cause of overpressure, etc. In order to ensure the complete effectiveness of safeguards, it is worthy to take into account and to investigate procedures to ensure that the functionality is not affected by lack of training, inadequate maintenance, operator mistake, failures, etc...),

Once adequacy of safeguards has been demonstrated, typical representation, taking a potential overpressurization case as an example, is shown here below:

- PI-1 provided with PAH and human response;
- PSHH-2 to activate logic I-1 closing XV-1;
- PSV-1.

4.2.6.5 Recording Summary

In the following table, a summary of the main rules to be followed during HAZOP review and relevant recording.

1	Define the "battery limits" for cause and consequences.
2	Identify all the possible consequences associated to each cause, taking into account the objective of the analysis.
3	Consequences and relevant dynamics shall be properly described, including final scenarios.
4	Please avoid cross references between deviation; describe the scenario as soon as the it can be highlighted and don't remind to next deviations. Only in the following deviation it can be mentioned, making reference to previous deviations.
5	List all the available safeguards according to layer of protection approach, starting from alarm and human response, then interlocks and at the end mechanical and passive protections (following the dynamics of the scenario).
6	Remember that we can take credit on safeguards when they completely fulfil the following requirements: independency and effectiveness.
7	Full recording shall be adopted, if not otherwise clearly specified.

Table 5 – HAZOP main rules

4.2.7 Recommendations

Where a potential hazard is identified, remedial action (recommendations) may be required depending on several factors, such as the likelihood of the event and the relevant magnitude of consequence, the poor availability / effectiveness of existing safeguard, etc. The recommendation is identified univocally by means of a code number shown on worksheet and need to be implemented in the revision of the drawings or addressed to additional studies and/or calculations (follow-up step).

As a general rule, the recommendations are worded in the following way:

- the words “Provide” or “Add” or “Change” or “Relocate” are used when the need for the required action are fully agreed within the Team, based on the available information;
- the word “Evaluate” are used when further consideration is required to the current design for any reason;
- the words “Verify” or “Ensure” are used to request further verification of specific items/features or consequences.

Recommendation shall be collected and included in the HAZOP report in a dedicated “action list”, where will be specified who is in charge for each action (“owner”).

In case further improvement / additional safeguards are required, if an immediate solution is available and acceptable to the team, it shall be recorded in the worksheet. On the contrary, where solutions are unlikely to be derived, without a technical evaluation, the Chairperson shall refer the problem for a separate assessment.

Discussion of problems/technical improvements out of the scope of the meeting and not under evaluation shall be kept to a minimum, together with re-design of the systems, which shall be avoided.

If required by Clients, agreed safety changes, including all queries, might be marked in red on the HAZOP Master P&IDs and possibly identified by a unique reference number.

If HAZOP is performed on existing plant, having the purpose to lower the risk level, prioritization of recommendation would be necessary to prepare a schedule associated to risk reduction plan for implementation of recommended actions.

4.2.8 Selection of proper type of HAZOP

Level of detail, accuracy and objectives of a HAZOP study are related to the stage in the life-cycle of the project; depending on it, proper approach shall be adopted, as shown in the following table:

Type of HAZOP	**COARSE HAZOP**	**MAIN HAZOP**	**FINAL HAZOP**	**HAZOP FOR R.A.**
Project life-cycle stage	Project conceptual design	FEED	EPC / Execution phase	Existing plant
Objective	Highlight major hazards and possibility to change the design (including inherently safe design criteria)	Highlight process hazards (to verify if the unit will operate in safe manner); to analyse relationship with other units and to highlight possible major operational upsets. No changes on design are expected as an outcome of the HAZOP review.	Analysis of packages provided by Vendors To confirm proper close out of recommendation arisen from Main HAZOP Procedural HAZOP	Analysis related to process risks including those related to operations
Documentation	PFDs Preliminary P&IDs (if available)	PFDs / H&MBs P&IDs and defined equipment / lines / instrumentation / PSVs data sheets	PFDs / H&MBs P&IDs issued for construction, C&E matrix, Data sheets	PFDs / H&MBs P&ID as built C&E matrix, Data sheets Operating procedures
Notes		Any further change in documentation to be managed by proper MOC procedure May be required for changes / modification to existing units or to review procedures	Unit ready for construction / operation after final HAZOP	Existing unit
Parameters and Guidewords	Main	Main and possible additional specific guidewords	Main and possible additional specific guidewords used in FEED	Main

Table 6 – Level of detail, accuracy and objectives of a HAZOP

4.3 DESCRIPTION OF HAZOP STUDY OPERATING PHASES

4.3.1 Main phases of HAZOP study

The HAZOP review process flow can be represented as follow:

1) Study preparation
   - Collection of reference documentation;
   - Nodes identification;
   - HAZOP team composition;
   - Scheduling / planning.

2) HAZOP review sessions
   - "Brainstorming" meeting involving the whole multidisciplinary HAZOP team, systematically applying guidewords to each parameter, node by node;
   - "Wrap-up" meeting at the end of the session.

3) Reporting
   - Preparation and issue of preliminary draft;
   - Comments;
   - Final issue.

4) Follow-up
   - Implementation of actions in the next stage of the project.

   This step is fed by HAZOP process but it is not included in the HAZOP review itself.

Figure 2 – HAZOP Workflow

4.3.2 Phase 1 – Study preparation

During this preliminary phase the following activities are foreseen for a successful development of the next stages:

- Collection of reference documentation;
- Nodes identification;
- HAZOP team composition;
- Scheduling / planning.

4.3.2.1 Documentation

Documentation strictly necessary for the development of the HAZOP study is reported:

- Process and Utilities Basis of Design;
- Process description;
- Process Flow Diagram – PFD (or PFS);
- Utility Flow Diagram – UFD (or UFS);
- Heat and Material Balance (HMB);
- Project P&ID (or PEFS);
- Plot Plan;
- Cause & Effect matrix;

- Control, shutdown and process safeguarding philosophy (ESD Philosophy);
- Blow down, flaring and venting philosophy;
- Equipment and machinery data sheets;
- Piping data sheets;
- Pressure relief devices data sheets.

The above mentioned documentation (in particular the ones from point 1 to 6) shall be received by the Chairperson at least one week before the starting of the sessions.

The following documents shall be available in case of need:

- MSDS (Material Safety Data Sheets) of dangerous substances;
- detailed thematic plot plans, e.g. active fire systems, smoke/fire/gas detectors location, sewer networks, etc.;
- operating, maintenance and emergency procedures /manuals, if available according to the stage of the project.

4.3.2.2 Nodes identification

Before starting HAZOP session, HAZOP nodes will be identified by Chairperson on PFDs and UFDs by marking –up the drawings. Identified nodes shall be submitted to Client for approval.

Nodes will be marked-up on the relevant P&Ids during the HAZOP session.

4.3.2.3 HAZOP team

The HAZOP sessions, shall include following experts:

- HAZOP Chairperson;
- HAZOP Scribe;
- Lead HSE Engineer / HAZOP focal point / co-ordinator;
- Lead Process Engineer;
- Process Engineer;
- Process/Operation Specialist;
- Instrument Engineer (on call);
- Mechanical / maintenance Engineer (on call).

The tasks of the HAZOP “key figures” and other team members are described here below:

- **Chairperson** is an experienced technical person, who is responsible for nodes identification, leading the study with appropriate guidewords, establishing the detailed work schedule together with HAZOP focal point, ensuring that procedure is followed and that notes and results of the study are properly recorded and distributed, resolving any conflict that may arise during the study, ensuring that the team works toward a common goal by utilising expertise of all team members, and checking on the progress of the study. Furthermore, the Chairperson is responsible to verify the work progress in accordance with the schedule: this include taking/suggesting any corrective action required to prevent unwanted delay.
- **Scribe** is responsible for preparing HAZOP worksheets, HAZOP action list and HAZOP report, and recording and filing all documents (including attendance list) used and generated during the study in accordance with instructions of the Chairperson. She/he is also responsible for distributing HAZOP worksheets to attendees and specialists concerned.
- **HAZOP focal point** is responsible to arrange the meeting and to select the members of the working team; and additional and primary task is to collect the documentation and to distribute it to the

members. She/he is also in charge for establishing the detailed work schedule together with HAZOP Chairperson and to ensure that from a logistic point of view everything is fine. In case of controversy related to the scope of work of the projects, is responsible for clarifying and fixing out the project's boundaries.

- **Other Team Members** are responsible for providing comments based on their knowledge and experience to assist the team in resolving issues emerging during the study.

4.3.2.4 HAZOP schedule

HAZOP schedule is prepared by the HAZOP Chairperson in co-operation with the HAZOP focal point, mainly basing on the following parameter:

- number of nodes;
- complexity of nodes (the higher the number of items in the node and the complexity of the process, the longer the average duration of analysis on each node);
- stage of the project (e.g. HAZOP performed during early stage of the project, since detailed information and drawings are not available takes less time than an HAZOP performed on later stages).

Following general criteria can be followed to prepare the HAZOP schedule:

- 2 ÷ 4 nodes per day for continuous process units (with nodes previously identified on PFDs);
- 3 ÷ 5 nodes per day for batch operations (e.g. fuel terminal operations);
- 3 ÷ 4 P&ID per day assuming one P&ID relevant to single node/equipment or operation.

4.3.3 Phase 2 – HAZOP sessions

HAZOP session will be held according to methodology described on Chapter 4.2.

4.3.3.1 Logistics

For successful development of HAZOP analysis sessions, the availability of a dedicated meeting room of suitable dimensions and windows, with large table and a video projection system for showing to all participants the worksheets in progress is strongly required.

It is also recommendable the availability of a suitable number of copies of P&IDs to be distributed to each participant (also in A3 format) plus one copy (in original size) to be used as master copy of the session, where nodes will be marked-up over and which will be preferably hung on the meeting room walls.

HAZOP meeting is normally scheduled with two distinct sessions (morning and afternoon) of maximum three hours each one and suitable breaks (coffee/tea break of 10-15 minutes for each session and a lunch break of at least one hour).

HAZOP Team has the responsibility to be focused on HAZOP objectives, avoiding inconclusive discussions, in order to cope with scheduling agreed.

4.3.3.2 Attendance list

During the sessions, the list of participants to HAZOP session will be daily recorded on dedicated sheets according to ICARO MOD-CT01-01 format (or equivalent), including:

- Name;
- Company;
- Role/Discipline;
- Signature.

4.3.3.3 P&IDs Master Copy

Nodes will be highlighted on large size P&Ids (preferably ISO A1 or ISO A2) during the sessions. Master copy should be signed-in by Chairperson and representative of the Companies involved at the end of HAZOP workshop.

After signature they will be scanned to be attached to the HAZOP report.

4.3.3.4 Wrap-up meeting

At the end of the session, few hours shall be spent for a wrap-up meeting addressed to review the action arisen from HAZOP and the main topics. Following the wrap up, the list of recommendation shall be considered fully agreed by the team members.

4.3.4 Phase 3 – Reporting

A dedicated HAZOP report will be issued at the end of the sessions describing the following main topics:

- Scope of the study;
- Process descriptions;
- Methodology description;

- Table of deviations;
- Daily attendance list;
- Nodes list;
- Reference documentation;
- P&IDs used for the HAZOP sessions (marked-up “master copies”);
- HAZOP worksheets;
- Recommendations (actions) list.

A preliminary draft of the report is usually issued for comments one week after completion of the review. Since worksheets are supposed to be projected, in a manner that all participants can check, verify and agree what has been recorded, worksheet can be issued and distributed for information only. If required, worksheet can be printed out at the end of the session and signed by the key-figures.

4.3.5 Phase 4 – Follow-up

Follow-up phase is the latest stage of an HAZOP review; during the phase the implementation of HAZOP recommendation is monitored (“follow-up” or “close-out” register) to ensure that all the action arisen from HAZOP will be included in the next stage of the project.

However, follow-up stage shall be considered a dedicated step, which will be managed separately by the Client.

ATTACHMENT 1 – HAZOP WORKSHEET

Study		**Node**	
Client		**Node Intention**	
Plant			
Session n° / date		**Temperature**	
Chairperson		**Pressure**	
Team		**Flow rate / Capacity**	
		Composition / other	
		Drawing n.	
Notes			

Parameter	Guideword	Causes	Consequences	Safeguards	Recommendations	By (Owner)
Flow	None/Less					
	More					
	Less					
	Reverse					
	Misdirect					
Temperature	More					
	Less					
Pressure	More					
	Less/Vacuum					
Level	More					
	Less/No					
Composition	Other Than					
Other	Lack of utilities					
	Start-up/shut-down					
	Maintenance / isolation					
	Other					

ATTACHMENT 2 – SOME CRITERIA FOR EVALUATION OF CONSEQUENCES

Here below some additional technical criteria to be used as a reference to evaluate the consequences. These criteria may vary or be reviewed and defined according to project specifications.

HP/LP systems interface ("gas break-through")

Shall be considered the maximum operating pressure on the HP system vs. design pressure of the LP system. If maximum operating pressure on the HP system cannot be defined, the relevant design pressure shall be considered. Same assumption to be applied in case of reverse flow (gas / vapour phase).

Overfilling

In case of overfilling, shall be verified first if adequate inherently safe systems are in place to prevent overpressurization (e.g. open vent adequately sized to handle the incoming flow rate). If available, the relevant scenario shall be the outflow of the processed product. If not, overpressurization may be expected. The maximum operating pressure of the incoming product shall be considered vs. the design pressure of the potentially overfilled equipment; if the fluid is transferred by means of centrifugal pumps, the relevant shut-off pressure. For other cases the design pressure of the system upstream the equipment shall be considered. Same assumption will be applied in case of reverse flow (liquid phase).

Blocked outlet

As reference pressure shall be considered the maximum operating pressure on the upstream system vs. design pressure of involved system. If the fluid is transferred by means of centrifugal machinery, the relevant shut-off pressure shall be considered. For other cases the design pressure of the system upstream the equipment shall be considered.

Reverse flow

Over pressurization case cannot be excluded even though check valves are provided; as defined by API 521 std. and therefore PSV shall be verified also for this scenario (relief load for PSVs can be assumed as 10% of maximum theoretical flow-rate if two check valves, dissimilar type e periodically tested are provided, API 521, § 4.3.4.4).

Tube rupture case (tube&shell heat exchangers)

Over pressurization case can be excluded when tube&shell heat exchangers are designed at list according to 10/13 ASME rule ore more stringent codes.

External fire case

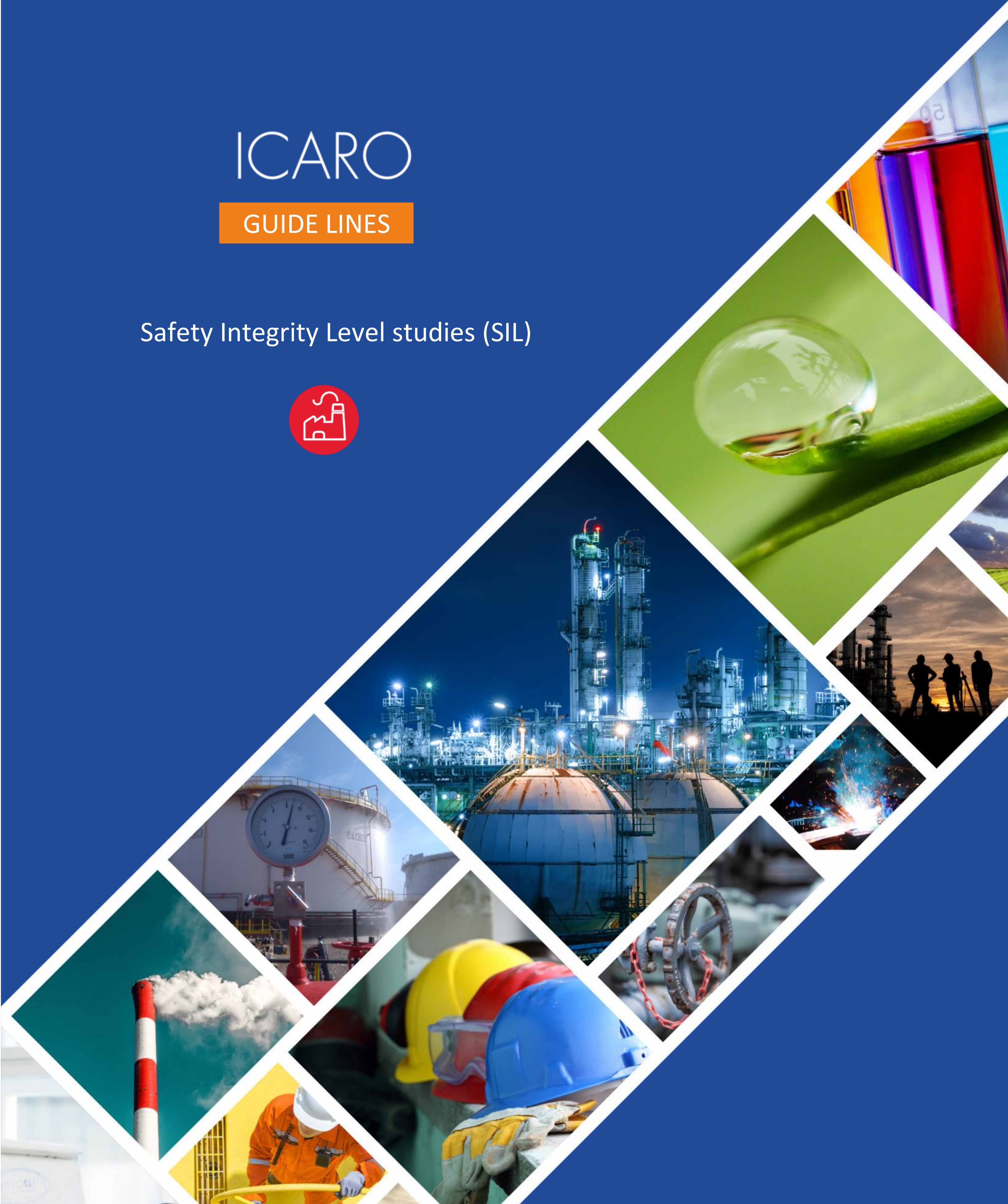
External fire case shall be always verified. Any exclusion for PSV requirement shall be justified.

For fixed roof atmospheric tanks this scenario shall be verified as well (according to std. API 2000 § 4.3.3) unless the tank is provided with frangible welding of the fixed roof (see std. API 650).

ICARO

GUIDE LINES

Safety Integrity Level studies (SIL)



PROPOSED	CHECKED	APPROVED	REV.	DATE	DESCRIPTION
F.Bindi	N.Manning	B.Frattini	03	31/01/2018	Updating
F.Bindi	N.Manning	M.G.Ruffi	02	10/11/2014	Updating
F.Bindi	N.Manning	M.G.Ruffi	01	01/03/2014	Updating
G.Monanni	N.Manning	M.G.Ruffi	00	19/11/2007	First iusse

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INDEX

1. SCOPE

This procedure defines modalities and methodologies to be followed in developing the Safety Integrity Level - SIL- studies, including Allocation Requirement and Verification phases.

Industrial risk is usually conceived as a measure of human injury, environmental damages or economic losses in combined terms of both the probability and the magnitude of injuries, damages and losses, following a major accident. A major industrial accident is generally caused by an initial a loss of containment and further release of material and/or energy in the environment, able to origin hazardous effects for humans, environment and properties. An accident may evolve in several forms (different scenarios). For example, a release of toxic and concurrently flammable substances may result in:

- fires (immediate ignition at the release);
- flash fire (delayed ignition of a limited quantity of vapours in air);
- vapour cloud explosion (delayed ignition of a significant amount of vapours);
- toxic cloud dispersion (no ignition).

For each scenario, the hazardous effects assume different characteristics, all endangering humans, environment and property as for instance:

- radiation waves, from fires and fireballs;
- pressure waves, from explosions, both confined and unconfined;
- toxic contaminations, in air, soil or water, capable to lead to immediate or delayed effects.

Consequences of hypothesized accidents are measured by the intensity/gravity of the effects in relation to the threshold vulnerability limits and to the extension/expositions of human beings, of the environmental components and of the properties affected. In order to minimise the probability of occurrence of accidents and to minimise the consequences in case an accident occurs, the Safety Integrity Level (SIL) analysis of emergency/trip functions is performed. The SIL analysis is a systematic activity that includes both allocation and verification to be performed to all emergency/trip functions. The technique uses a team of reviewers with expertise in several key areas. The Safety Integrity Level analysis developed in ICARO complies with international standards as well as with the EU regulations, descending by the first Seveso Directive and further amendments.

2. REFERENCES

2.1 Reference guidelines

- IEC 61508:2010 Part 1÷7 “Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems”;
- IEC 61511:2016 Part 1÷3 “Functional safety – Safety Instrumented Systems for the Process Industry Sector.

2.2 Reference documents

Main reference documents to be made available during Hazop analysis are the following:

- Piping and Instrumentations diagrams (P&Ids);
- Emergency system design philosophy;
- Cause & Effects diagrams;
- Pressure safety valves data sheets;
- Process description;
- Piping general arrangement;
- Plant/unit blow down report.

Moreover, the following documents should be available in case of need:

- Equipment and piping data sheets;
- Operating, maintenance and emergency procedures/manuals;
- Process Flow Diagrams (PFD);
- Heat and Material Balance (H&MB);
- Plant plot plans;
- Detailed plot plans, e.g. active fire systems, smoke/fire/gas detectors location, sewer networks, etc.

3. DEFINITIONS AND ACRONYMS

3.1 Definitions

Basic Process Control System — The system that responds to input signals from the process and generates output signals to maintain operation of the process in a desired state. The system does not perform functions assessed as SIL 1 or higher.

Beta Factor — The number of Common Mode Failures (of robust Initiators or Final Elements), expressed as a fraction of all possible Failures.

Common Mode Failure — A Failure having the potential to affect all duplicated components in a robust configuration by virtue of common or shared characteristics.

Dangerous Failure — A Failure that has the potential to place the SIL/IPF in a state in which it will fail to perform its function. Dangerous Failures are usually only safe when the system has to perform a certain action or through testing. Also known as unrevealed failure.

Dangerous Failure Rate — The number of Dangerous Failures per unit time.

Dangerous Failure Robustness — A configuration in which plant integrity is not jeopardised by the Dangerous Failure of a single SIL/IPF component. Also known as unrevealed failure robustness.

Demand — A process or equipment condition or event which requires an IPF / SIF to take action to prevent a Hazardous Situation.

Demand Rate — The frequency at which a Demand occurs, i.e., the number of Demands per unit time.

Diagnostic Coverage Factor — The number of Dangerous Failures that diagnostic features are capable of detecting, expressed as a fraction of all possible dangerous failures.

(NOTE: Diagnostic features may only be recognised as such if they can trip the process to a safe state or maintain safety by different means.)

Failure — An abnormal condition that may cause a reduction or loss of capability of the IPF to perform its intended function.

Final Element — A device, or combination of devices, that manipulate a process variable or attract the attention of the operator to achieve risk reduction. The Final Element includes output cards or output relays, solenoid valves and cabling. Examples are valves, switchgear (rotating equipment stop circuits) and alarms.

Hazard or Hazardous Situation — A situation with the potential to cause harm, including ill health and injury, damage to property, products or the environment, production losses or increased liabilities.

Hazard Rate — The frequency at which Hazardous Situations occur per unit time.

Hazard Rate = Demand rate x Probability of Failure on Demand.

Initiator — A device, or combination of devices, that indicates whether a process or equipment item is operating outside the operating envelope. The Initiator includes input cards and input relays. Examples are manual switches, position switches and measurement systems (including process connections, sensors, transmitters, cabling, trip amplifiers or input cards etc.).

In IEC 61508/61511 an Initiator is referred to as a Sensor.

Independent Protection Layer — IPL. Device, system, or action that is capable of preventing a postulated accident sequence from proceeding to a defined, undesirable endpoint. An IPL is (1) independent of the event that initiated the accident sequence and (2) independent of any other IPLs. IPLs are normally identified during layer of protection analyses.

Inspection Time — Time interval between proof tests

Instrumented Protective Function	A function comprising one or more Initiators, a Logic Solver and one or more Final Elements whose purpose is to prevent or mitigate hazardous situations. An IPF is intended to achieve or maintain a safe state for the process, in respect of a specific hazardous event. In IEC 61508/61511 an IPF is referred to as a SIF.
Instrumented Protective System / Safety Instrumented System	The electromechanical, electronic and/or programmable electronic Logic Solver component of the Instrumented Protective Function, complete with input and output equipment. In IEC 61508/61511 an IPS or SIS are referred to as a 'Logic Solver'.
Logic Solver	The portion of an IPF / SIF that performs the application logic function. The Logic Solver excludes trip amplifiers, input cards and output cards. Examples are electromechanical relays, solid-state/magnetic-core logic and the CPU section of programmable electronic systems.
Mean Time To Restoration	Time interval to repair the failing component. Includes repair time, shipping and managing time
Mitigation	The action of making a consequence less severe or relieving consequences.
Partial Valve Stroke Test	Technique to test a percentage of the possible failure modes of a valve without the need to physically fully close the valve itself.
Probability of Failure on Demand	The probability (dimensionless) of the IPF or SIS failing to respond to a Demand.
Programmable electronics	Electronic component or device forming part of a PES and based on computer technology. The term encompasses both hardware and software and input and output units. (NOTE: This term covers micro-electronic devices based on one or more CPUs together with associated memories, etc. Examples of process sector programmable electronics include: smart sensors; final elements; and programmable electronic logic solvers, such as, programmable controllers, PLCs, DCS, loop controllers.)
Programmable Electronic System	System for control, protection or monitoring based on one or more programmable electronic devices, including all elements of the system such as power supplies, sensors and other input devices, data highways and other communication paths, actuators and other output devices. As an example, an IPS or SIS could be a PES.
Proof Test	A test carried out on IPF components against an approved procedure to confirm that all requirements of the IPF are met.
Proof Test Coverage Factor	The number of Dangerous Failures detected by the Proof Test expressed as a fraction of all possible dangerous failures.
Risk	The frequency at which a Hazardous Situation occurs multiplied by the consequence of the Hazardous Situation.
Risk Reduction Factor	Is the contribute on an IPL to reduce risk allocated.
Safe Failure	A Failure whose occurrence does not have the potential to place an IPF in a dangerous state. Also known as revealed failure.
Safe Failure Rate	The number of Safe Failures per unit time.
Safe Failure Fraction	The safe failure fraction (SFF) is the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault.
Safety Integrity Level	Dangerous failure class 1, 2, 3 or 4 derived from the consequences of failure on demand and the frequency of demand. The definition in IEC 61511: discrete level (one out of four) for specifying the safety integrity requirements of the IPF / SIF to be allocated to the SIS (trip systems). Safety integrity level 4 has the highest level of safety integrity; safety integrity level 1 has the lowest.
Trip	An Instrumented Protective Function action to bring the Final Element to a safe state.
Undetected Failure	A failure that is not detected by internal diagnostics
Validation	Confirmation that the system under consideration fully meets the integrity requirements set forth in the associated IPF Requirements Specification.
Verification	Demonstration for a particular life-cycle phase that all deliverables (documents, software, hardware) meet the objectives set for that phase.

3.2 Acronyms

BDV	Blow-Down Valve
BPCS	Basic Process Control System
C&ED	Cause and Effects Diagram
DCS	Distributed Control System
ESD	Emergency Shut Down
ESDV	Emergency Shut Down Valve
F&G	Fire and Gas
HAZOP	Hazard and Operability study
HFT	Hardware Fault Tolerance
IE	Initiating Event
IEC	International Electrotechnical Commission
IPL	Independent Protection Layer
IPF	Instrumented Protective Function
IPS	Instrumented Protective System
LOPA	Level Of Protection Analysis
MTTR	Mean Time To Restoration
P&Id	Piping and Instrumentation Diagram
PE	Programmable Electronics
PES	Programmable Electronic System
PLC	Programmable Logic Controller
PFD	Probability of Failure on Demand
PSV	Pressure Safety Valve
PVST	Partial Valve Stroke Test
SDV	Shut Down Valve
SFF	Safe Failure Fraction
SIF	Safety Instrumented Function
SIL	Safety integrity Level
SIS	Safety Instrumented System
TI	Inspection Time

4. CONTENTS

4.1 SIL methodology

4.1.1 Foreword

A Safety Integrity Level (SIL) analysis is a key step in the Safety System Design Process. While the HAZOP process normally discovers potential hazards and provides general recommendations, the SIL is a specific analysis which defines the Safety Criteria and Mitigation of hazards which can lead to a significant safety, environmental and economic consequences.

SIL analysis is performed according to the IEC 61508 [1] extensive standard, which is essentially a framework for implementing instrumented safety systems using the principle of Safety Life Cycle, and the IEC 61511 [2], developed as a Process Sector implementation of IEC 61508.

An important concept in the standard is that of the Safety Instrumented Function (SIF), which is a function to be implemented by a Safety Instrumented System (SIS) composed mainly by sensors (e.g. transmitters), logic solvers (E/E/PE) and final elements (e.g. solenoids), which is intended to achieve or maintain a safe state for the process, with respect to a specific hazardous event.

A SIS can be seen as a method to reduce the overall risk, acting as independent protection layer, as showed on the following figure.

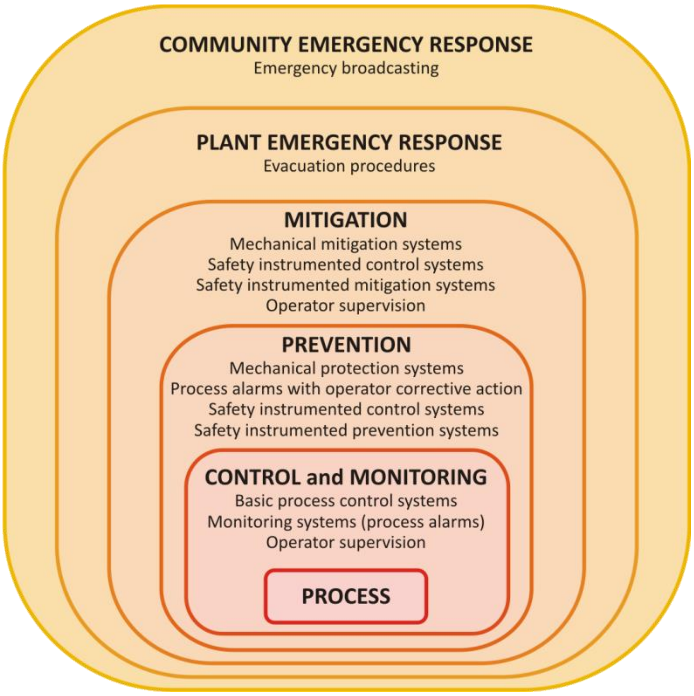


Figure 1 – Independent Protection Layers approach

From this point of view, an independent protection layer is a “system” fully independent from the others capable to reduce the risk, by preventive or protective actions, e.g. an explosion proof design, a PSV, a SIS, a F&G system, an emergency procedure, etc.

Each key SIF must be evaluated for the severity of the protected risk and the performance of the SIF must be commensurate with the risk. The performance level for each SIF must address both the reliability and availability requirements of the SIF. Both of these factors are combined into a single index termed SIL, which

[1] Functional safety of electrical/electronic/programmable electronic safety-related systems.

[2] Functional safety – Safety instrumented systems for the process industry sector.

is defined as the likelihood of the system satisfactorily performing the required safety function under all the stated conditions within a stated period of time.

The SIL ratings can be equated to the Probability to Fail on Demand (PFD), in a defined interval of time, of the relevant SIF. Relationship between SIL and Process Failure on Demand is indicated in the following table, in case of Shut Down Systems (not continuously operating systems[3]).

Safety Integrity Level (SIL)	Probability of failure on demand (PFD)
4	$\geq 10^{-5} - < 10^{-4}$
3	$\geq 10^{-4} - < 10^{-3}$
2	$\geq 10^{-3} - < 10^{-2}$
1	$\geq 10^{-2} - < 10^{-1}$

Table 1 - Relationship between SIL and Process Failure on Demand, low demand mode of operation

Same criteria apply also for the identification of the Asset Integrity Level of the plant/station. The analysis is to be done separately due to fact that productive asset is mainly linked to economic aspects (loss of production, loss of materials, etc.) and not necessarily linked with safety. Combined but distinct analysis allows to have a more complete picture of the risk and mostly to select the most appropriate level of protection.

The development of SIL analysis sessions usually requires the participation of following multidisciplinary experts:

- SIL analysis Facilitator (and Secretary), an independent expert in safety and reliability, who has the duty to guide the SIL Team through the application of all necessary phases of the analysis;
- Process and Instrument engineers, with the task to provide necessary technical information and answers to the questions of the Facilitator;
- Project Engineer, with the task to support the SIL Team with specific considerations from project management point of view.

The proposed methodology shall be applied to all protective functions, as detailed on the cause & effect diagrams/matrixes.

4.1.2 Logic scheme

The overall logic scheme of the so called SIL Assessment process is shown by the following flow chart:

[3] Low Demand Mode: where frequency of demands for operation made on a safety-related system is no greater than one per year and no greater than twice the proof-test frequency (IEC 61508-4).

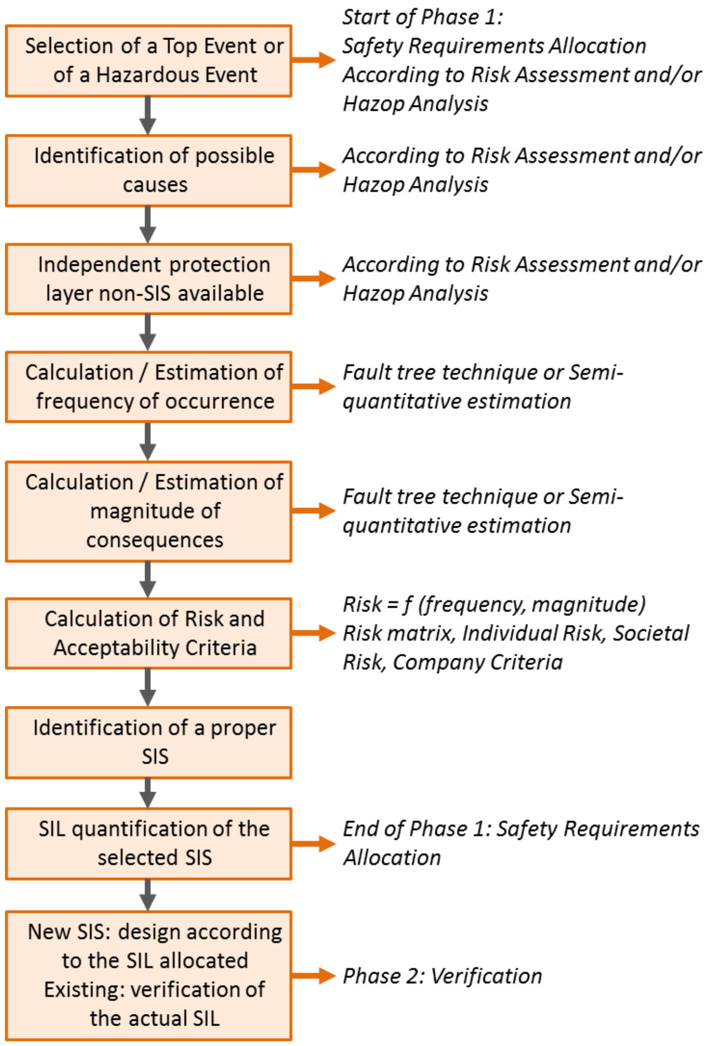


Figure 2 – SIL Assessment process

4.1.3 Methodology

SIL analysis is performed in two phases:

a) **Safety Requirements Allocation**: allocation of the most appropriate SIL to each SIF, by means of the evaluation of demand rate and magnitude of consequences, considering the SIF assessed not in place. The IEC 61508 does not provide a mandatory way to perform the safety requirement allocation phase; here are provided the following three suggested methods:

- Risk Graph;
- Risk Matrix.

Relevant details are provided below. In case, a different method can be followed, according to Client's specifications.

b) **Verification**: quantitative verification, according to the IEC-61508, that the proposed designing of the relevant SIS is conforming to the SIL required.

4.2 PHASE 1 – SAFETY REQUIREMENTS ALLOCATION

As a general point view, SIL analysis is the systematic assessment of key logic functions designed to manage the Emergency Shut Down of the process plant, as detailed in the Cause & Effects Diagram.

Logic steps to develop the SIL Allocation process are the following:

a) brief introduction and description of the process;
b) analysis of Cause & Effects diagrams;
c) selection of first logic function (Safety Instrument Function, SIF) to analyse and analysis of design intent;
d) selection of the safety requirement allocation method;
e) evaluation of demand rate (frequency of occurrence) and magnitude of consequences in case of failure on demand;
f) evaluation of additional parameter required by the method selected;
g) evaluation of SIL requested to the SIF selected by application of the selected safety requirement allocation method;
h) analysis of consequences of spurious trip, if necessary;
i) selection of following logic function to analyse and actions from d) to h).

Procedure is applied in a systematic way up to final completion of all the logic functions to be analysed; when a SIF is analysed, it is assumed that all other SIFs function correctly.

Safety requirements allocation results are reported on the format provided on the **Attachment 1**.

4.2.1 The Risk Graph method

Risk is defined as a combination of the probability of occurrence of harm and the severity of that harm (see Clause 3 of IEC 61511-1). Typically, in the process sector, risk is a function of the following four parameters:

Parameter		Description
Consequence of the hazardous situation	**C**	Number of fatalities and/or serious injuries likely to result from the occurrence of the hazardous event. Determined by calculating the numbers in the exposed area when the area is occupied taking into account the vulnerability to the hazardous event.
Occupancy (probability that the exposed area is occupied)	**F**	Probability that the exposed area is occupied at the time of the hazardous event. Determined by calculating the fraction of time the area is occupied at the time of the hazardous event. This should take into account the possibility of an increased likelihood of persons being in the exposed area in order to investigate abnormal situations which may exist during the build-up to the hazardous event (consider also if this changes the C parameter).
Probability of avoiding the hazardous situation	**P**	The probability that exposed persons are able to avoid the hazardous situation which exists if the safety instrumented function fails on demand. This depends on there being independent methods of alerting the exposed persons to the hazard prior to the hazard occurring and there being methods of escape.
Demand rate (number of times per year that the hazardous situation would occur in the absence of the safety instrumented function being considered)	**W**	The number of times per year that the hazardous event would occur in the absence of the safety instrumented function under consideration. This can be determined by considering all failures which can lead to the hazardous event and estimating the overall rate of occurrence. Other protection layers should be included in the consideration.

Table 2 - SIL Allocation Parameters

RISK GRAPH

The required SIL of the selected SIF is established according to a semi-quantitative way proposed by the IEC-61511. The Risk Graph procedure is shown by the following figure:

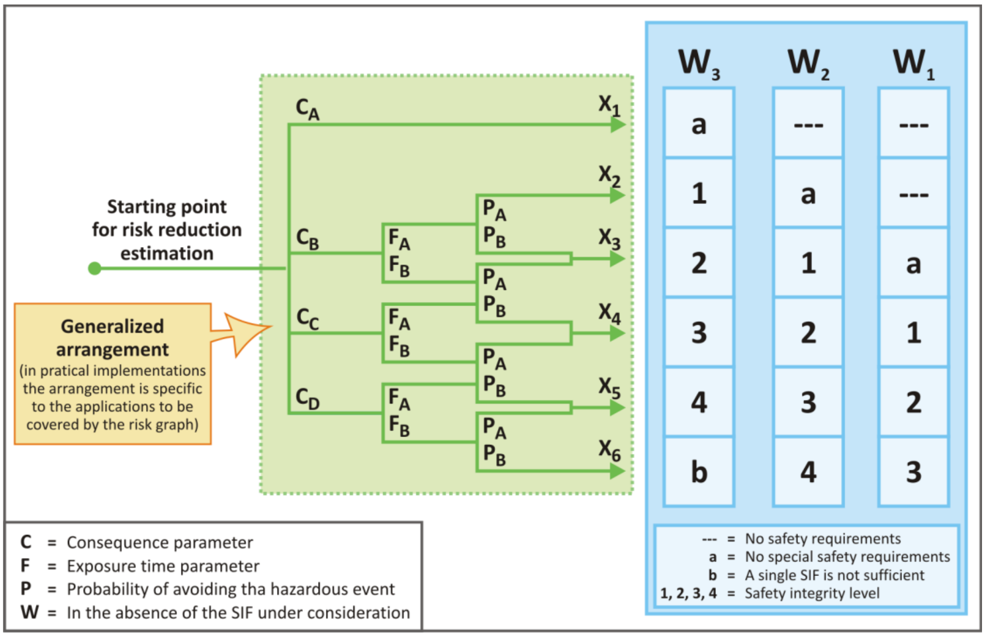


Figure 3 - Risk Graph for SIL Allocation

Calibration of the risk graph is the process of assigning numerical values to risk graph parameters in order to:

- describe all parameters in such a way as to enable the SIL assessment team to make objective judgements based on the characteristics of the application;
- ensure the SIL selected for an application is in accordance with corporate risk criteria and takes into account risks from other sources;
- enable the parameter selection process to be verified.
- The following calibration is proposed by the IEC-61511 as an example.

CONSEQUENCES (TO PEOPLE)

Risk parameter		Classification	Comments
Consequence (C) Number of fatalities	C_A	Minor injury	1 The classification system has been developed to deal with injury and death to people.
This can be calculated by determining the numbers of people present when the area exposed to the hazard is occupied and multiplying by the vulnerability to the identified hazard.	C_B	Range 0,01 to 0,1	2 For the interpretation of C_A, C_B, C_C and C_D, the consequences of the accident and normal healing should be taken into account.
The vulnerability is determined by the nature of the hazard being protected against. The following factors can be used:	C_C	Range >0,1 to 1,0	
V = 0,01 Small release of flammable or toxic material V = 0,1 Large release of flammable or toxic material V = 0,5 As above but also a high probability of catching fire or highly toxic material V = 1 Rupture or explosion	C_D	Range >1,0	

Table 3 - Risk Graph – Consequences to People

CONSEQUENCES (TO ENVIROMENT)

Risk parameter		Classification	Comments
Consequence (C)	C_A	A release with minor damage that is not very severe but is large enough to be reported to plant management	A moderate leak from a flange or valve Small scale liquid spill Small scale soil pollution without affecting ground water
	C_B	Release within the fence with significant damage	A cloud of obnoxious vapour travelling beyond the unit following flange gasket blow-out or compressor seal failure
	C_C	Release outside the fence with major damage which can be cleaned up quickly without significant lasting consequences	A vapour or aerosol release with or without liquid fallout that causes temporary damage to plants or fauna
	C_D	Release outside the fence with major damage which cannot be cleaned up quickly or with lasting consequences	Liquid spill into a river or sea A vapour or aerosol release with or without liquid fallout that causes lasting damage to plants or fauna Solids fallout (dust, catalyst, soot, ash) Liquid release that could affect groundwater

Table 4 - Risk Graph – Consequences to Enviroment

OCCUPANCY

Risk parameter		Classification	Comments
Occupancy (F) This is calculated by determining the proportional length of time the area exposed to the hazard is occupied during a normal working period. NOTE 1 If the time in the hazardous area is different depending on the shift being operated then the maximum should be selected.	F_A	Rare to more frequent exposure in the hazardous zone. Occupancy less than 0,1	3 See comment 1 above.
NOTE 2 It is only appropriate to use F_A where it can be shown that the demand rate is random and not related to when occupancy could be higher than normal. The latter is usually the case with demands which occur at equipment start-up or during the investigation of abnormalities.	F_B	Frequent to permanent exposure in the hazardous zone	

Table 5 - Risk Graph – Occupancy

PROBABILITY OF AVOIDING THE HAZARDOUS SITUATION

Probability of avoiding the hazardous event (P) if the protection system fails to operate.	P_A	Adopted if all conditions in column 4 are satisfied	4 P_A should only be selected if all the following are true: – facilities are provided to alert the operator that the SIS has failed;
	P_B	Adopted if all the conditions are not satisfied	– independent facilities are provided to shut down such that the hazard can be avoided or which enable all persons to escape to a safe area; – the time between the operator being alerted and a hazardous event occurring exceeds 1 hour or is definitely sufficient for the necessary actions.

Table 6 - Risk Graph – Consequences

DEMAND RATE

Demand rate (W) The number of times per year that the hazardous event would occur in absence of SIF under consideration. To determine the demand rate it is necessary to consider all sources of failure that can lead to one hazardous event. In determining the demand rate, limited credit can be allowed for control system performance and intervention. The performance which can be claimed if the control system is not to be designed and maintained according to IEC 61511, is limited to below the performance ranges associated with SIL1.	W_1 W_2 W_3	Demand rate less than 0,1 D per year Demand rate between 0,1 D and D per year Demand rate between D and 10 D per year For demand rates higher than 10 D per year higher integrity shall be needed	5 The purpose of the W factor is to estimate the frequency of the hazard taking place without the addition of the SIS. If the demand rate is very high, the SIL has to be determined by another method or the risk graph recalibrated. It should be noted that risk graph methods may not be the best approach in the case of applications operating in continuous mode, see 3.2.43.2 of IEC 61511–1. 6 D is a calibration factor, the value of which should be determined sio that the risk graph results in a level of residuaal risk which is tolerable taking into consideration other risks to exposed persons and corporate criteria.

Table 7 - Risk Graph – Demand rate

AVAILABILITY OF INDEPENDENT PROTECTION LAYERS (IPLS)

In case of availability of an IPL, this acts reducing the level of SIL allocated, because participates to the overall integrity objective. The Risk Reduction Factor of an IPL is the reciprocal of relevant PFD.

An IPL meets the following criteria (from IEC 61511):

- Specificity: the protection layer is designed to prevent or mitigate the consequences of one potentially hazardous event. Multiple causes may lead to the same hazardous event, and therefore multiple event scenarios may initiate action by an IPL;
- Independence: the protection layer is independent of other protection layers if it can be demonstrated that there is no potential for common cause or common mode failure with any other claimed IPL;
- Dependability: the protection layer can be counted on to do what it was designed to do by addressing both random failures and systematic failures during its design;
- Auditability: the protection layer is designed to facilitate regular validation of the protective functions.

Examples of IPL and relevant RRF are provided on the following table.

Independent Protection Layer	RRF
Pressure Safety Valve (PSV)[4]	100
Rupture Diks	100
Basic Process Control Systems (independent)	10
SIF independent, allocated SIL 1 (PFDavg between 1*E-1 and 1*E-2	10
SIF independent, allocated SIL 2 (PFDavg between 1*E-2 and 1*E-3)	100
SIF independent, allocated SIL 3 (PFDavg between 1*E-3 e 1*E-4)	1000
Operator intervention (in presence of unambiguous alarm and enough time to evaluate and counteract)	10

Table 8 - IPL and relevant RRF

4.2.2 The Risk Matrix method

[4] PSV shall be verified for the scenario under assessment ant relevant discharge shall be routed to a safe position.

One qualitative method that enables the SIL of a SIF to be determined is the Risk Matrix method. This method applies knowledge of the risk factors associated with the equipment under consideration and the equipment control system to make that determination.

Where a qualitative approach is adopted, a number of parameters are introduced that together describe the nature of the hazardous situation when safety systems fail or are not available. One parameter is chosen from each of four sets, and the selected parameters are then combined to derive the overall Safety Integrity Level allocated to the safety related systems. These parameters:

- allow a meaningful graduation of the risk to be made, and
- contain the key risk assessment factors.

The following simplified procedure is based on following relationship:

R = f x C

R (Risk) is the combination (product) of occurrence of harm (frequency) and the severity of that harm (Consequence) and is considered, in this context, as having no safety-related systems in place.

f (Frequency) is the hazard rate of the hazardous event with no safety-related systems in place, i.e., the number of hazardous event per unit time.

C (Consequence) is the harm following an hazardous event (including ill health and injury, damage to property, products or the environment, production losses or increased liabilities).

RISK MATRIX FOR SIL REQUIREMENT ALLOCATION

The Risk Matrix has the duty to combine the Demand Rate for each logic function and the relevant Consequences in case of failure on Demand. The proposed matrix is showed below.

*

Demand rate		**SAFETY INTEGRITY LEVEL**			
Frequent (possibly every year)	1	SIL 1	SIL 2	SIL 3	SIL 4
Probable (Several times during life cycle)	2	SIL 1	SIL 1	SIL 2	SIL 3
Rare (possibly one time in the life cycle)	3	No action	SIL 1	SIL 2	SIL 3
Remote (not expected during life cycle)	4	No action	No action	SIL 1	SIL 2
		1	2	3	4
		Minor damage	Serious damage	Extensive damage	Large Scale damage
		GRAVITY of CONSEQUENCES			

NOTE*: If the hazard can be efficiently prevented by other measures, go one step below. Suitable prevention systems are the PSV. Alarms are considered as suitable system only if the alert is given with sufficient time interval to allow the operator taking the corrective actions. Otherwise derating is not allowed.

Table 9 - Risk Matrix for SIL Allocation

DEMAND RATE

The classification of Demand Rate is made according to the table below, showing also the application of some sample cases for frequency identification.

Frequency (event/year)	Demand Rate		Example
> 1	1	Frequent	▪ Control valve travels to fail safe position ▪ Wrong action for a seldom practised operation ▪ Untightness of a check valve ▪ Failure of a pump / compressor ▪ Critical failure of a non-fail safe control loop
0.1 - 1	2	Probable	▪ Control valve travels against fail safe position ▪ Wrong action during frequent operation ▪ Failure of electric motor ▪ Failure of compressor's seal ▪ Tube rupture within a heat exchanger ▪ Critical failure of a fail-safe control loop ▪ Failure of DCS ▪ Total failure of a well maintained check valve
0.01 – 0.1	3	Rare	▪ Critical failure of a fail-safe PLC shut down ▪ Total failure of a check valve with special safety demands
< 0.01	4	Remote	▪ Has never been recorded in similar plants of the company

Table 10 - Risk Matrix - Demand Rate

For more detailed analysis, it is suggested to perform the evaluation of the Demand Rate by means of the Fault Tree techniques. The numerical results of Fault Tree Analysis are executed with specific software (e.g. the ASTRA - FTA, released by the European Joint Research Centre).

Reliability data for the analysis of the single events will be taken from industrial experience and from the internationally accepted sources, such as:

- Supplier's data;
- "The Cremer & Warner Report" – 1981;
- DNV Technica, "E&P Forum Report" – 1992;
- F.P. Lees, "Loss prevention in the chemical industry", IV Edition – 1992;
- CCPS/AIChE;
- R&M consultant;
- SINTF 2003 "Reliability Data Instrumented System";
- Exida "Safety Equipment Reliability Handbook".

CONSEQUENCES

The classification of gravity of the consequences is made according a set of criteria which identify the risks in terms of human beings, the environment and the economic losses connected to the failure on demand of the logic function. The matrix for identification of gravity of consequences is indicated in the table below.

Selection of consequences gravity category is connected to the highest possible category for each analysed task (injuries, environment).

Gravity		Personnel	Environmental
1	Minor damage	Small/minor injuries	On unit release of non-toxic substance (low concentration at ground level)
2	Serious damage	Major injuries	On site release of toxic substances / Off Unit release of non-toxic substance
3	Extensive damage	At least one fatality and necessity for external treatment	Release of toxic substances on site and Off Unit.
4	Large Scale damage	Multiple fatalities	Large release of toxic substances on and Off Site

Table 11 - Risk Matrix - Gravity of consequences

If the hazard could be prevented by other technical measures (e.g. alarms on same or other process parameters), availability of other protection layers (e.g. presence of PSV), then the SIL Team has the possibility to reduce of one order the level of frequency of the expected event, reducing the SIL accordingly to the Matrix.

Regarding the Consequences for personnel, specific reference to the effective presence of the operator in the hazardous area is made in order to select the most appropriate level of consequences.

For this purpose, the following matrix is applicable. The matrix provides guidelines to establish the level of consequence to the personnel as function of the typology of incident and to differentiate the final consequence level in relation to the effective presence of personnel in the plant area.

The first step for this calculation is to use the table in the lower side of the matrix, which defines:

- by row the possible typology of scenario (fire/explosion, fragmentation, poisoning);
- by columns the possible dimension of the scenario (e.g. for the case of fire, three possible cases are suggested: flange leakage, pipe fitting rupture, release from process equipment, according to increasing level of consequences).

Once the typology of scenario is selected, it is necessary to select the Exposure time, in accordance to the indications provided by the table in the right side of the matrix. This table defines by rows two different level of exposure:

- rare exposure, which foresees that the permanence of personnel in the area of potential damage is limited in time (typical case is the area of a not permanently manned plant in which presence of personnel is foreseen only during maintenance and inspections)
- frequent exposure, which foresees that the area of potential damage is permanently manned (typical case is a control room or a manned control panel).

After selection of the two cases, it is necessary to pass through the main table and individuate the corresponding value of Consequence level.

For example, in the hypothesis that the scenario is a release from a flange in a not permanently manned area, the corresponding value of Consequence level is set equal to 1.

The philosophy at the base of such analysis is that in case the scenario is located in a not permanently manned area, the potential consequence for people are judged to be less critical than the same scenario where presence of people can be considered as permanent. The final consequence is therefore derated of one level, which at the end means also that required SIL for the protection loop is derated of one level.

	CONSEQUENCES FOR PERSONNEL			Exposure Time Risk	
	1	2	3	0.1	**Rare exposure** in the endangered zone (10% of the time): ▪ only during inspections or maintenance ▪ if the remedial for accident does not require personnel in the endangered zone
	2	3	4	1	**Frequent or permanent exposure**: ▪ manned control panel for machinery ▪ if the remedial for accident requires personnel in the endangered zone ▪ control room ▪ residential area if the extent of the accident is over the site fence
	CAUSES				
Risk of fire / explosion	Leakage at flange	Release from a pipe fitting	Major release from a process equipment		
Risk of fragmentation	No such risk	Damage of pressurised systems; fragmentation of minor equipment	Damage of pressurised systems; fragmentation of major equipment		
Risk of poisoning	Release of small amount of toxic substances	Minor release of toxic substances	Major release of toxic substances		

Table 12 - Definition of Gravity of consequences for personnel

4.3 PHASE 2 – VERIFICATION

After the identification of SIL levels that each single trip logic has to satisfy, the SIL analysis requires the operative numerical check on the basis of the proposed design

In this stage, SIL Verification of each Safety Instrumented Function (SIF) shall be performed through the following steps:

- Logical representation of the SIF architecture;
- Gathering of the reliability data of each SIF component;
- Calculation of total PFD of SIF and verification that calculated PFD and relevant calculated SIL level are consistent with the requirement arisen in SIL Allocation phase;
- Verification of the architectural requirements (Hardware fault tolerance / Safe Failure Fraction) for each component of the SIF, as per paragraph 7.4.3 of IEC 61508-2 and tables 2 and 3 (subsystem of type A or B).

4.3.1 Representation of SIFs Architectures

In order to properly define the logical path that leads to a SIF unavailability (failure on demand), it is necessary to identify the architecture of each safety instrumented function.

For a correct and effective analysis, architectures of each SIF shall be sketched up showing:

- Sensors (e.g. pressure transmitters, etc.): in case of more than one sensor, the voting system shall be specified;
- Logic solver;
- Final Element/Elements (e.g. valves); in case of more than one sensor, the voting system shall be specified.

According to the voting system of the above mentioned elements, the logical diagram is drawn.

An example of SIF architecture sketch is shown in **Attachment 2**.

As far as final elements are concerned, it has to stressed that only the actions necessary to put in safe condition the system to be protected by the SIF have to be identified, neglecting all the complementary action which might be triggered by the same logic (shown in cause and effects matrixes).

All the actions not necessary to reach the safe condition of the system to be protected will not be taken into account in SIL Verification step, and thus they will be neglected in SIF Architecture definition.

4.3.2 Reliability Data collection

For every component of each Safety Instrumented Function reliability data shall be collected basing on the following sources:

- component's certificates (to be preferred, if available) or other technical documents provided by vendor;
- reliability data from Exida "Safety Equipment Reliability Handbook".

Main reliability data to be collected and used in PFD calculation are summarised in the following table.

Parameter	Description
λ_{DD}	Dangerous Failure Rate – Detected
λ_{DU}	Dangerous Failure Rate – Undetected
MTTR	Mean Time To Restoration
SFF	Safe failure fraction
T_I	Time interval between proof tests
ß	Fraction of undetected failures that have a common cause
$ß_D$	Fraction of detected failures that have a common cause

Table 13 - Main reliability data required for SIL Verification

If Common Cause Failure factors (ß and $ß_D$) for redundant elements are not available, it will be generally assumed as 5% of dangerous undetected failure rate.

It is generally assumed that maintenance capability is 100%, which means that repairable components are "as good as new" once restored after failure detection during maintenance.

Following table summarizes the main aspects to be clarified in order to properly use the data from components certificates or to correctly choose the reliability figures in previously mentioned Exida data base.

SIF Element	Information
Sensor (e.g. level transmitter)	Displacement, radar, etc.
Logic Solver	To be considered as overall package unit/ to be analysed in single sub-components (input module, output module, main processor / s etc.)
Valve (solenoid)	2-ways, 3-ways, etc.
Valve (actuator)	Linear, quarter turn, etc.
	Single effect (spring return), double acting, etc.
	Pneumatic, hydraulic etc.
	Provided with PVST (Partial Valve Stroke Test) or not
Valve (body)	Ball, gate, etc.
	Clean/ severe service
	Close on trip/ open on trip

SIF Element	Information
	Fail open/ fail close
	Required TSO or not
	Provided with PVST (Partial Valve Stroke Test) or not

Table 14 - Additional information required for SIL Verification

4.3.4 Reference for the selected reliability values

The reliability data shall be preferably taken from certificates / other technical documentation of the vendor.

The use of information from databank shall be limited as much as possible since it would lead to the following consequences:

- incertitude that the selected figures are effectively representative of the actual components;
- usually higher values of PFDavg leading to excessively conservative calculation.

In case that vendor's data are not available, the reliability data can be taken from the following source:

- "Exida 2007: Safety Equipment Reliability Handbook, Exida – 3rd Edition, 2007".

4.3.5 Application of availability models in order to establish the overall PFD of the complete loop

Average value of Probability of Failure on Demand (PFD) calculation of the whole safety function is performed in accordance with IEC 61508-6.

In order to evaluate the overall PFD of the loop, following formula applies:

$$PFD_{SYS} = PFD_S + PFD_{LS} + PFD_{FE}$$

being:

- PFD_{SYS} Average Probability of Failure on Demand of Safety Function
- PFD_S Average Probability of Failure on Demand of Sensor
- PFD_{LS} Average Probability of Failure on Demand of Logic Solver
- PFD_{FE} Average Probability of Failure on Demand of Final Element

The average PFD calculation will be performed by means of software such as FTA-Pro by IHS, basing on Fault Tree Analysis (FTA) technique for quantitative calculation of systems unavailability.

Fault trees are built basing on the logic architecture of each Safety Instrumented Function analysed and using as input data the specific reliability figures collected for every component.

The Unavailability (Q) of the Safety Instrumented Function calculated at the medium point of mission time is assumed as average value of probability of failure on demand for the SIF under examination.

An example of FTA graphic outline and relevant calculation results is showed in **Attachment 3**.

In the following paragraphs some example of mathematical simplified formula for PFD calculation, as provided by IEC 61508-6, are described.

SINGLE ELEMENT (1 OO 1 LOGIC)

$$t_{CE} = \frac{\lambda_{DU}}{\lambda_D} \cdot \left(\frac{T_1}{2} + MTTR\right) + \frac{\lambda_{DD}}{\lambda_D} \cdot MTTR$$

$$PFD_G = (\lambda_{DU} + \lambda_{DD}) \cdot t_{CE}$$

being:

- λ_D Element dangerous failure rate

- λ_{DD} Element dangerous failure rate – detected
- λ_{DU} Element dangerous failure rate – undetected
- MTTR Element Mean Time To Restoration
- T_1 Time interval between proof tests
- t_{CE} Channel Equivalent Mean Down Time
- PFD_G Average Probability of Failure on Demand of the group

REDUNDANT ELEMENTS (1 OO 2 LOGIC)

$$t_{CE} = \frac{\lambda_{DU}}{\lambda_D} \cdot (\frac{T_1}{2} + MTTR) + \frac{\lambda_{DD}}{\lambda_D} \cdot MTTR \quad ; \quad t_{GE} = \frac{\lambda_{DU}}{\lambda_D} \cdot (\frac{T_1}{3} + MTTR) + \frac{\lambda_{DD}}{\lambda_D} \cdot MTTR$$

$$PFD_G = 2 \cdot ((1-\beta_D) \cdot \lambda_{DD} + (1-\beta) \cdot \lambda_{DU})^2 \cdot t_{CE} \cdot t_{GE} + \beta_D \cdot \lambda_{DD} \cdot MTTR + \beta \cdot \lambda_{DU} (\frac{T_1}{2} + MTTR)$$

being the parameters not defined in previous paragraph:

- t_{GE} Voted Group Equivalent Mean Down Time
- ß Fraction of undetected failures that have a common cause
- $ß_D$ Fraction of detected failures that have a common cause

REDUNDANT ELEMENTS (2 OO 3 LOGIC)

$$t_{CE} = \frac{\lambda_{DU}}{\lambda_D} \cdot (\frac{T_1}{2} + MTTR) + \frac{\lambda_{DD}}{\lambda_D} \cdot MTTR \quad ; \quad t_{GE} = \frac{\lambda_{DU}}{\lambda_D} \cdot (\frac{T_1}{3} + MTTR) + \frac{\lambda_{DD}}{\lambda_D} \cdot MTTR$$

$$PFD_G = 6 \cdot ((1-\beta_D) \cdot \lambda_{DD} + (1-\beta) \cdot \lambda_{DU})^2 \cdot t_{CE} \cdot t_{GE} + \beta_D \cdot \lambda_{DD} \cdot MTTR + \beta \cdot \lambda_{DU} (\frac{T_1}{2} + MTTR)$$

The parameters have been already defined in previous paragraphs.

4.3.6 PFD average requirement for Verification

The SIF designed is positively verified in case:

$$PFD_{SYS} = \geq PFD_{\mathrm{Re}\,quested}$$

4.3.7 Architectural requirements for Verification

With reference to IEC 61511-1, apart from verification of calculated average PFD / calculated SIL level with the required PFD/ SIL level from SIL Allocation, there is a further requirement to be satisfied for every subcomponent of each safety instrumented function.

For all components, according to the Hardware Fault Tolerance available, the Safe Failure Fraction shall be inside the range correspondent to the SIL level required for the SIF.

The following tables show the SFF required for components of type A, elements with low complexity (sensors, final elements and non-PE logic solvers) or type B, elements with high complexity (PE logic solvers):

Safe Failure Fraction	Hardware fault tolerance		
	0	1	2
< 60 %	SIL 1	SIL 2	SIL 3
60% - < 90%	SIL 2	SIL 3	SIL 4
90% - < 99%	SIL 3	SIL 4	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

Table 15 - Hardware safety integrity: architectural constraints on type A safety-related subsystems (ref. Table 2 of IEC 61508-2)

Safe Failure Fraction	Hardware fault tolerance		
	0	1	2
< 60 %	Not allowed	SIL 1	SIL 2
60% - < 90%	SIL 1	SIL 2	SIL 3
90% - < 99%	SIL 2	SIL 3	SIL 4
≥ 99%	SIL 3	SIL 4	SIL 4

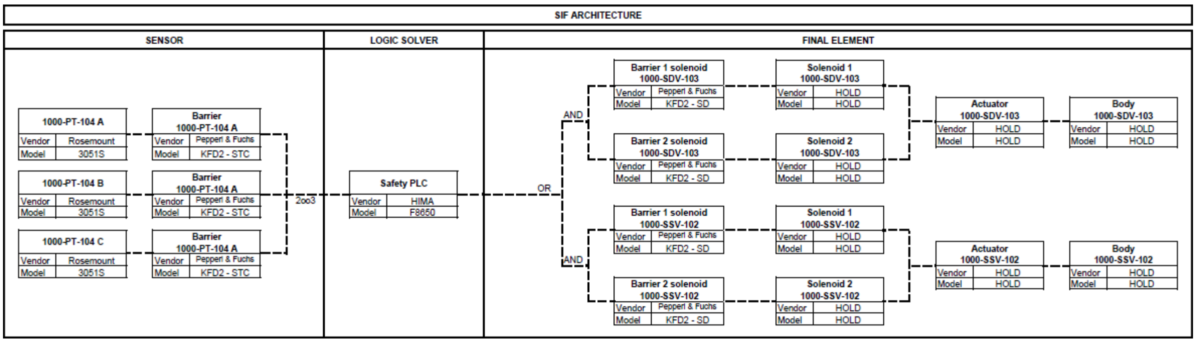
Table 16 - Hardware Safety Integrity: architectural constraints on type B safety-related subsystems (ref. Table 3 of IEC 61508-2)

ATTACHMENT 1 – SIL ALLOCATION WORKSHEET

Study		Unit	
Client		Equipment / Line from	
Plant			
Meeting		Line to	
Leader		Function	
Team		Presence od additional safety barrier	
		C&E Diagram n.	
		P&I Diagram n.	
Notes			
Description of logic function		**SIL Assessment**	
TAG initiator		Demand rate	0
TAG logic solver		Consequences of failure on demand (safety, environment)	0
TAG actuator		Calculated SIL	
Design intent		Selected SIL	
Demand scenario		Consequences of failure on demand	0
Consequences of failure on demand		Calculated AIL	
Consequences of spurious trip		Selected AIL	
Notes			
Demand rate			
Level of consequences			
Safety			
Environment			
Asset			

Note: the matrix allows the possibility for the SIL Team to select a different SIL from the calculated one. The calculated SIL represents the rigorous value obtained from the loop architecture. The selection of the SIL Team might revise the calculated SIL in order to take into account other available devices in the process circuit that might prevent the request for the automatic trip (e.g. presence of alarms on same or other process variable).

ATTACHMENT 2 – EXAMPLE OF SIF ARCHITECTURE



ATTACHMENT 3 – EXAMPLE OF PFD CALCULATION BY FTA