LNG Liquefaction Plant
Project Compliance to EN 13645

Project Compliance to EN 13645 for LNG Liquefaction Plant
Verification Report

REV.	DATE	REVISION TITLE	PREPARED	CHECKED	APPROVED
D1	07/09/2023	Final Issue	Giacomini	Silvi	Antonelli
D0	24/03/2023	Final Issue	Giacomini	Silvi	Antonelli
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INDICE

1 INTRODUCTION

The Company Bioplus LNG GmbH intends to proceed with the construction of a natural gas liquefaction plant, to be installed at Renzenhof (Germany).

The intervention consists in the construction of an LNG liquefaction plant; in this plant the natural gas will be liquefied through a recycle nitrogen closed circuit, working at cryogenic temperature. The process consists of the following main stages:

- Natural gas treatment;
- Liquefaction Process;
- LNG storage and tanker loading.

SIAD MI is the Company in charge of the engineering, procurement and construction of the main part of the LNG liquefaction plant.

1.1 Purpose of the Document

The purpose of the present document is to present the verification of the Project compliance to the standard of reference EN 13645 (Ref [1]) – “Installations and equipment for liquefied natural gas - Design of onshore installations with a storage capacity between 5 t and 200 t”.

In particular, the document is divided in the following main sections:

- ANNEX A: Verification of the Project Compliance to EN 13645:2001 – Check list
- ANNEX B: Accidental Scenario Analysis
- ANNEX C: Consequences Analysis Mapping

1.2 List of abbreviations

The following abbreviations and/or acronyms will be used in the present study without the need to be further clarified:

ALARP	As Low As Reasonably Practicable
BOG	Boil Off Gas
C&E	Cause & Effect Matrix
ETA	Event Tree Analysis
F&G	Fire & Gas
HSE	Health, Safety and Environment
LCR	Local Control Room
LEL	Lower Explosive Limit
UEL	Upper Explosive Limit
LNG	Liquefied Natural Gas
NG	Natural Gas
KO	Knock Out
OGP	Oil & Gas Producers
TE	Top Event
TSA	Temperature Swing Adsorption
VCE	Vapour Cloud Explosion

1.3 Normative and Standards

The following references have been considered for the development of this document:

1.3.1 Standards

Ref.	No. Document	Title	Date
[1]	EN 13645	Installations and equipment for liquefied natural gas - Design of onshore installations with a storage capacity between 5 t and 200 t	2001
[2]	OGP report No. 434 – 01	OGP – Process Release Frequencies	2019
[3]	OGP report No. 434 – 06	OGP - Ignition probability	2019
[4]	UK HSE failure data	Failure Rate and Event Data for use within Risk Assessments	2019
[5]	-	TNO “Purple Book” Guidelines for Quantitative Risk Assessment	1999
[6]	-	TNO “Yellow Book” Methods for the calculation of Physical Effects due to releases of hazardous materials (liquids and gases)	2005
[7]	OGP Standard 434-15	OGP - Vulnerability of plant-structure	2010
[8]	UK HSE CRR 183	Development of methods to assess the significance of domino effects from major hazard sites	1998

1.3.2 Project documentations

please double check the mentioned revisions, for some I found new revisions, what is cortrect?

Ref.	No. Document	Title	Rev.	Date
[9]	140REZH690010001 PFS001 (SWDS271/5)	Cause & Effect Matrix	0C	14/03/23
[10]	520REZH700001000SRI002 (I20784)	Piping and Instrumentation Diagram	0D?	13/03/23
[11]	520REZH598004003 SRI00 (2220698-0B-10-001 / EST105704)	NG Treatment Unit - Piping and Instrumentation Diagram	0D?	12/03/23
[12]	520REZH700001000 SGR001 (I20785)	Process Flow Diagram	0C?	30/01/23
[13]	520REZH690010001 RBA001 (GTS24/525)	Plant Process and Operating Description	0A	06/02/23
[14]	900REZH690001000 PLY001 (I28783)	Plant layout with tie-in points	0P?	16/03/23
[15]	GTS19/819	Procedure for LNG Truck Loading	0A	23/02/23

[16]	690REZH730001000YDT001 (GTS19/817)	Pollutants Vents and Drain Table	0B	24/03/23
[17]	140REZH690010001PEX001 (AA120)	ESD Pushbuttons and F&G Devices Layout	0B	17/03/23
[18]	520REZH690010000PEX001 (I21005)	Plant layout with ATEX classified area	0A	10/03/23
[19]	520REZH730001030UBE001 (EST109978)	Vent, Hot Flare and Thermal Oxidizer Declaration	0A	14/06/23
[20]	900REZH6900010001UBE00201 (GTS24/529)	Risk Analysis – HAZOP Report	0A	21/04/23

1.3.3 Software

Ref.	Software	Developer	Version
[21]	PHAST	DVN-GL	8

2 PROJECT/ PROCESS DESCRIPTION

In the LNG Liquefaction Plant, natural gas (NG) is liquefied using nitrogen as cooling medium.
Before being liquefied, natural gas needs to be purified in order to remove elements that can freeze at cryogenic temperature (mainly carbon dioxide and water).
Natural gas coming from the fiscal metering station is pre-heated in a steam heat exchanger before entering the purification unit; a small flow of natural gas is depressurized in a pressure reduction station and sent to a thermal oxidizer and to a steam boiler as fuel gas.
Natural gas is treated inside purification unit in order to be decarbonized and dried.
Purification system is based on an ammine system composed by a CO2 absorption unit, a solvent addition and removal unit, a stripping unit for carbon dioxide removal and a NG precooling and drying unit for water removal.
The ammine unit (selective solvent) removes carbon dioxide and sulphurs in order to obtain a concentration of few ppm in feed natural gas flow.
Purified natural gas enters in the adsorption tower where the acid gas (mainly carbon dioxide) is stripped with a counter current washing with ammine solution.
Exiting from adsorption tower, natural gas is cooled and sent to TSA drying unit.
After the dehydration the natural gas is sent to the liquefaction unit.
The LNG liquefier cold box package contains all equipment needed to liquefy natural gas with a recycle nitrogen closed circuit working at cryogenic temperature. The refrigerant fluid is nitrogen.
All cryogenic equipment (heat exchanger, valves, piping) is installed inside a vertical enclosure made in carbon steel; hollow space between cold box internal equipment is filled with perlite, a material that thermally insulate the cold parts. Inlet and outlet turbine piping, filters and turbine trip valves are installed inside a carbon steel turbine duct directly connected to the cold box.
Outside cold box, a KO drum collects the LNG drain in case of plant shut-down. Vaporized liquid is sent to the cold box.
The natural gas coming from purification unit enters inside the primary heat exchanger where is cooled and liquefied and then subcooled inside the LNG subcooler. LNG enters then inside the LNG separator where the incondensable gases (mainly nitrogen and hydrogen mixed with others hydrocarbons) are separated from LNG flow. The flow rich of nitrogen and hydrogen is heated inside the HC heater and then burnt in the thermal oxidizer. The liquid natural gas is stored into the LNG storage tanks.
A small flow of nitrogen is required to reintegrate the nitrogen leakages from compressor and turbines/boosters seals, for purging of flare and vent lines/PSV discharge lines and for cold box inertization.
Nitrogen is supplied by a liquid nitrogen storage system. Nitrogen needed to reintegrate the leakages and purging is taken from the tanks and vaporized and heated up inside the liquefier cryogenic exchanger.
LNG product is stored inside the LNG storage tanks. Each tank is connected to one LNG truck loading pump which transfers the LNG from tank to truck. The boil off gas produced during the truck loading is recovered inside the storage tanks as long as pressure in the tanks is low enough; if pressure inside the tanks increases, boil off is sent to BOG compressor and recirculated at gas treatment inlet after being heated inside the HC heater.

ANNEX A - CHECK-LIST

In the following tables is presented, for each paragraph of the reference standard EN 13645 (Ref [1]), the verification of the Project compliance.

[…]

4 – ENVIRONMENTAL IMPACT

4.1 – General

	Compliance verification	**NOTES**
An environmental impact study shall be carried out when the LNG storage capacity exceeds the threshold specified in the local regulation. If this value is not available, a threshold of 50 t is recommended. The impact study shall take into account any restrictions on the transportation of LNG. All emissions from the plant, that is, solid, liquid (including water), and gaseous (including noxious odors) shall be identified. Measures shall be implemented to ensure that normal and accidental emissions are harmless to persons, property, animals or vegetation. An effluent management policy shall be established if relevant. The requirements in the handling of any toxic materials shall be identified.	**Verified**	Environmental impact assessment concluded with the following design requirements, already implemented in the Project: 1 – flammable fluid emissions during the plant shutdown for emergency conditions are vented to cold flare; 2 – during the normal plant stop only NG regeneration compressor and BOG compressor are depressurized and vented to the cold flare. The Regenerative Thermal Oxydizer remains in operation to burn the waste gas from cold box evaporation and BOG; 3 – during the plant depressurization after a normal stop for maintenance the flammable gas is recovered by a mobile compressor or is vented to hot flare. Hot flare is switched ON by operator according to the maintenance procedure; 4 – Continuous CO_2 and uncondensable gas vents from cold box during operation are burned into the Regenerative Thermal Oxydizer; 5 –combustion wastes of steam boiler and Regenerative Thermal Oxydizer are within the limits of Regulation TA Luft 2021 and VDI 3896; 6 – Regulation AwSV and DWA-A 780-1 is applied to prevent water pollution. For details of pollutants, vents and drains refer to document 690REZH730001000YDT001 (GTS19/817, Ref. [16])- Pollutants vents and drain table.

	Compliance verification	**NOTES**
Any increase in activity caused by operation shall also be assessed and undesirable levels of activities shall be eliminated if possible or minimized and restricted. The following items should be considered:		
- noise levels;	**Verified**	The noise levels of the activities have been assessed and the design take in consideration the acceptable thresholds.
- vibration levels;	**Verified**	The vibration levels of the activities have been assessed and the design take in consideration the acceptable thresholds.
- night working, effect of lights;	**Not Applicable**	Negligible effect.
- gas flaring or venting;	**Verified**	The heat radiation and gas dispersion levels of the activities have been assessed and the design take in consideration the acceptable thresholds defined at chapter 5.3.2 and 5.3.3 of this standard EN 13645 (Ref. [1]).
- warming or cooling of water.	**Not Applicable**	Cooling water is in close circuit with thermal power dissipated in ambient air.

4.2 – Emission Control

	Compliance verification	**NOTES**
The following shall be safely controlled:		
- combustion products from compressor drivers, submerged vaporizers, fired heaters for regeneration;	**Verified**	Applicable only to Regenerative Thermal Oxydizer and steam boiler. Combustion products are in accordance with Regulation TA Luft 2021 and VDI 3896.
- normal or accidental venting of gases;	**Verified**	Cold and hot flare systems are designed for safe disposal of flammable gas.
- normal or accidental flaring of gases;	**Verified**	Cold flare has provision of automatic CO_2 extinguishing system, in case of accidental vented gas ignition. Hot flare is used for maintenance activity only.

	Compliance verification	NOTES
- oily water condensed during dryer regeneration or from machines;	**Verified**	Oil circuit of machineries is equipped with drip panel to collect the leakages. Oily water drainage from Instrument air compressor is equipped with oil separator.
- in the case of water-cooled equipment, hydrocarbon contamination of this water from leaking exchanger tubes;	**Verified**	Water flowing inside coolers of Regeneration gas compressor, coolers of BOG compressor and NG regeneration cooler is in close circuit. Water inside the baths of HC heater and NG regeneration heater is not drained during operation.
- disposal of waste products (chemicals, waste oil and chlorinated organic compounds);	**Verified**	Waste product disposal will be in accordance to Local Regulation. Waste management system will be detailed during next design phase.
- vaporizer water;	**Not Applicable**	No water vaporizer is foreseen in the plant.
- odorant chemicals.	**Not Applicable**	Odorization is not present in the process.
The standard of emissions control shall follow as a minimum specifications set by local regulation.	**Verified**	The following regulations are applied: -TA Luft 2021 and VDI 3896; - AwSV and DWA-A 780-1.

4.3 – Boil-off / flash gas management

	Compliance verification	NOTES
Continuous flaring or venting shall be avoided. Boil-off gas can be recycled in a liquefaction process or included in the send-out gas to avoid waste gas during normal operation.	**Verified**	A Boil-off gas compressor is foreseen to recycle the gas to the inlet and mix it with the feed gas, as shown in Project P&IDs - Doc. No. 520 REZH700001000SRI002 (I20784, Ref. [10]). Only the incondensable stream with high content of nitrogen and hydrogen is combusted inside the Regenerative Thermal Oxydizer.

4.4 – External communication networks

	Compliance verification	**NOTES**
Traffic rates of external roads, railways and waterway networks near the LNG plant shall be identified.	**Verified**	Adequate external communication networks have been identified for the LNG liquefaction Plant.

5 – SAFETY PLAN

	Compliance verification	**NOTES**
LNG installations shall be designed to minimize the risks to property and life outside and inside the plant. A safety plan shall be defined during the design of the plant or during a major modification when the LNG storage capacity exceeds the threshold specified in the local regulation. If this value is not available, a threshold of 50 t is recommended. The safety plan shall include an identification of risks and an appropriate appraisal of the consequences. It shall also include the safety measures and principles of the actions performed by the operator for controlling risks for accidents. Implementation of the safety plan shall be initiated as early as possible and be reviewed when unacceptable risks are identified during the design. A hazards and operability study (HAZOP or equivalent) shall be conducted to identify and eliminate or minimize hazards. Annex A illustrates the schematic description of the process related to an LNG satellite and fuelling plant. This description is simplified and it is not considered to be directly applicable for an actual project.	**Verified**	An accidental scenarios analysis has been conducted in order to assess the safety distances to be maintained within the plant installation (e.g. between process equipment, storage and buildings) and plant boundaries, determined in accordance with thresholds limits provided in paragraph 5.3 of Ref. [1]. The analysis is shown in Annex B and C. An HAZOP Analysis has been carried out (Ref. [20]). Cold vent flare is used in emergency condition and for the depressurization of the NG regeneration compressor and BOG compressor during the normal stop. The radiation thresholds as per par. 5.3.2 of Ref. [1] are applied, with respect to process equipment, building and storage vessels, as stated in doc. “Vent, Hot Flare and Thermal Oxidizer Declaration” (Ref. [19]).

6 – GENERAL SAFETY MEASURES

6.1 – Leaks and spillage protection

	Compliance verification	**NOTES**
6.1.1 - Detection system		
Correct design, fabrication, construction and operation will minimize the quantity and frequency of leaks of flammable fluids. However, where leaks can occur and can escalate to a more serious incident, consideration shall be given to the installation of fixed leak detection systems with executive action to stop the leak source, to isolate relevant sections of plant and to shutdown sources of ignition in the vicinity.	**Verified**	The plant is equipped with a F&G system based on the following detectors types distributed in the whole area: - flammable gas detectors - flame detectors - ultrasonic detectors - thermoelements - oxygen poor atmosphere detectors - smoke detectors For detailed description of detector actions and location refer to docs. 520REZH690010001RBA001 (GTS24/525) – Plant process and operating description, 140REZH690010001PEX001 (AA120) – ESD pushbuttons and F&G devices layout and 140REZH690010001PFS001 (SWDS 271/5) - Cause & Effect Matrix (Ref. [13], [17] and [9]).
6.1.2 - Piping and equipment		
Contraction/expansion phenomena due to temperature variations can induce material fatigue and create significant stresses in pipework and equipment leading to ruptures. To avoid this risk or to reduce the consequences, the following arrangements should be taken:		
- the number of flanges in pipe runs should be minimized. When it is possible, valves should be welded in line;	**Verified**	The number of flanges in piping has been minimized. For LNG and BOG piping the valves are Butt-weld or socket weld type.
- the orientation of relief valve outlets shall be such as to minimize hazards. When a jet stream occurs, it shall not reach nearby equipment or people;	**Verified**	Relief valves disposal collected to Cold vent system. (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
- piping design shall take account of all operating conditions;	**Verified**	All operating conditions are considered in piping design.

	Compliance verification	**NOTES**
- systems shall be designed to avoid excessive operation of relief valves;	**Verified**	Design conditions determined with respect to operating conditions, in order to avoid excessive operation of relief valves. In addition, a boil-off gas recycled system is foreseen (Ref. doc. 520 REZH700001000SRI002 (I 20784) – P&I diagram, Ref. [10]).
- pumps with high integrity seals or submerged motors shall be used for LNG;	**Verified**	Submergible barrel pumps are considered in the Project.
- above ground vessels shall be located in the open;	**Verified**	Above ground vessels installed in open area. (Ref. Doc. 900REZH690001000PLY001, I20783 – Plant layout, Ref. [14]).
- equipment containing flammable fluid should be located in the open, but this recommendation can be affected by maintenance requirements or climatic conditions. In some circumstances, equipment may be installed in confined areas, for instance, to ensure an early detection of small gas releases or to contain high pressure jets. If installed in a confined area, this area should be ventilated. The air renewal rate shall be determined by an appropriate study;	**Verified**	Equipment containing natural gas are installed in open areas except for steam boiler (Ref. Doc. 900REZH690001000PLY001, I20783 – Plant layout, Ref. [14]).
- routing of pipework through concrete walls shall allow free expansion of the pipework.	**Verified**	Confirmed. Piping stress analysis will be developed during next design phase.
Non-visible parts of pipework endangered to corrosion shall be subject to special protection.	**Verified**	Confirmed. All piping is painted with a painting system according to ISO 12944 – part 2 & 5 - corrosivity class C3 for a minimum expected durability H. Cryogenic piping is not painted, due to the fact that is made of stainless steel material.
When under pressure, leaking valves or connections shall only be tightened using suitable tools and procedures.	**Verified**	Confirmed. Only no-sparking tools shall be used with flammable fluid service.
6.1.3 - Impounding areas		
If leaks of flammable liquids are considered to be a possible scenario, then the leaks should be confined by dykes. Flammable liquid flowing from a leak may be directed in open channels towards an impounding basin.	**Verified**	The LNG storage tanks are located within concrete basin, with containment wall and appropriate slope to channel any leakage towards a valved siphoned pit.

	Compliance verification	**NOTES**
The design of an impounding basin shall be such that flammable fluids do not enter the surface water drainage system.	**Verified**	Siphoned pits are provided in order to avoid LNG to come in contact with drainage water, since, in case of LNG release the water suddenly freezes inside the siphon.
Consideration shall be given to the installation of leak detection devices and means to control the evaporation rate in the impounding basin. The basin may be partitioned to reduce vaporization of LNG and therefore gas emission into the atmosphere.	**Verified**	Inside basin flammable gas detector and low temperature detector are installed. The activation of such detectors shutdowns the plant (including the truck loading bays) and isolates the tanks.
When pipework is routed through the wall of an impounding basin, a suitable seal shall be provided.	**Verified**	Confirmed.
6.1.4 - Protection against low temperature		
In the event of a leak, low temperature fluid can come into contact with metallic components which can fail due to embrittlement. Measures can be taken to prevent serious damage by suitable selection of materials of construction or by embrittlement protection such as insulation.	**Verified**	Piping and vessels in cryogenic service are in austenitic stainless steel, adequate for low temperatures conditions. In addition, low temperature detectors are foreseen inside the LNG tanks basin, initiating plant shutdown and depressurization.
6.1.5 - Isolation valves		
Isolation valves shall be fitted as close as possible to the nozzles of process liquid outlets of pressure vessels containing flammable liquids such as hydrocarbon refrigerants and LNG. These isolation valves shall be remotely closed either by automatic emergency shutdown or by manual action.	**Verified**	Emergency shut down valves on liquid outlets of storage tanks are installed close to the tanks, inside the basin and are remotely controlled by the ESD system.

6.2 - Overpressure protection

	Compliance verification	**NOTES**
Safety devices shall be designed to prevent overpressure inclusive of fire engulfment. The gas discharged from relief valves of vessels and vaporizers should be safely discharged directly to the atmosphere or in cases where discharge directly to atmosphere is considered unsafe a vent stack or a flare shall be employed.	**Verified**	Safety relief valve designed for external fire. Safety relief valves are collected to the cold flare disposal system. (Ref. doc. 520 REZH700001000SRI002 (I 20784) - P&I Diagram, Ref. [10])

	Compliance verification	**NOTES**
For other equipment, discharged gas shall be transferred to the flare/vent system or to the storage vessel. If the safety and environment assessment shows that the consequences of the discharge directly to the atmosphere are acceptable, then connection to the flare/vent system is not compulsory.	**Verified**	Safety relief valves are collected to the cold flare disposal system. (Ref. doc. 520 REZH700001000SRI002 (I20784) - P&I Diagram, Ref. [10]) During normal plant stop the flammable fluid is not vented, except for the NG regeneration compressor and BOG compressor, for which a depressurization is foreseen. In case of maintenance the flammable fluid is vented to the hot flare.
Automatic or semi-automatic emergency depressurization systems are recommended if fire insulation or a water deluge system is not installed. Isolation valves, activated from the control room or other remote location, shall be provided to isolate sensitive equipment.	**Verified**	Process sections are isolated by means of automatic ESD valves. The gas treatment (CO2 removal and dehydration) and liquefaction sections are automatically depressurized by intervention of the ESD system. For ESD system description refer to Doc. No. 520REZH690010001RBA001 (GTS24/525) – Plant process and operating description (Ref.[13])

6.3 - Fire protection

	Compliance verification	**NOTES**
The fire protection system shall include powder extinguishers in all cases. It shall be designed taking into account the reaction time and the firefighting equipment of the local fire service.	**Verified**	Firefighting system is foreseen and properly designed according to local regulations.
Alert systems such as break-glass units, telephones, paging systems, closed circuit television and sirens may be used.	**Verified**	Plant is suitable to be remotely controlled. CCTV and internal communication system are foreseen.
Measures to prevent the freezing of fire water circuits shall be provided.	**Verified**	Firefighting network will be underground to prevent freezing.

	Compliance verification	**NOTES**
If LNG storage exceeds 50 t, the fire protection system shall include foam generators for the impounding basin of the vessel, if any, or a validated system composed of material floating on the LNG surface (such as foamglass) which reduces its evaporation in order to keep the radiation fluxes of the LNG fire under the maximum values given in 5.3.	**Verified**	Foam system or other system for the impounding basin will be defined and provided with firefighting expert.

6.4 - Confinement

	Compliance verification	**NOTES**
Apart from intended situations (see 6.1.2, piping and equipment), confined or partially confined zones shall be avoided as far as possible, in particular:		
- gas and LNG pipework should not be situated in closed ducts;	**Verified**	Gas and LNG piping is not installed inside closed ducts.
- if there is a space under an aboveground vessel, it shall be large enough to allow air circulation;	**Verified**	The vertical above ground tanks are located in open area, allowing air circulation.
- ducts for cables, cable trays, etc. shall be filled with compacted sand and covered with flat slabs with ventilation holes.	**Verified**	The requisition is applied for ducts inside the process area with presence of natural gas and LNG.

6.5 – Emergency shutdown

	Compliance verification	**NOTES**
An emergency shutdown system independent from the process control system shall be provided.	**Verified**	An emergency shutdown system, independent by the control system, is foreseen. It is activated by the F&G system and by the push buttons located in the plant area and in control room. (Refer to doc. 520REZH690010001RBA001, GTS24/525 - Plant process and operating description and 140REZH690010001PEX001 (IAA120) – ESD pushbuttons and F&G devices layout, Ref. [17])

	Compliance verification	**NOTES**
When personnel are not permanently present on the site, an automatic system is required.	**Verified**	An emergency shutdown system independent by the control system is foreseen. If personnel is not present it is activated by the F&G system (Refer to doc. GTS24/525 - Plant process and operating description and 140REZH690010001PEX001 (IAA120) – ESD pushbuttons and F&G devices layout, Ref.[13] and [17]).
A shutdown system shall be provided to prevent embrittlement of the piping material due to low temperature downstream of the vaporizers.	**Verified**	The natural gas is stored and exported in the liquid phase and is not be gasified for gas export. Low temperature protection is provided downstream the HC heater to warm up the Boil off Gas.

6.6 – Commissioning and decomissioning

	Compliance verification	**NOTES**
Before the start of operation the commissioning tests shall be performed by an approved test engineer or expert.	**Verified**	Confirmed. Commissioning test will be attended by Notified Body.
All pressure loaded equipment shall be pressured and leak tested in accordance with the local regulation and the manufacturer's requirements.	**Verified**	Confirmed.
The procedures for commissioning and decommissioning operations shall be defined at the design stage. Drain circuits shall enable inerting and complete drying of main components and insulation spaces also.	**Verified**	Inertization with nitrogen is foreseen before start up and after the emergency depressurization.
All pipework circuits shall be inerted at the initial stage.	**Verified**	Nitrogen distribution network is connected to the process flow lines for inertization. (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I diagram, Ref. [10]).

6.7 - Inspection

	Compliance verification	**NOTES**
Testing shall follow the relevant standards and codes.	**Verified**	Confirmed.
The installation should allow external inspection of above ground vessels on all sides. The suitable space for maintenance and cleaning should be at least 1,5 m around the vessels.	**Verified**	The LNG tanks are located within concrete basin, accessible through stairs. Maintenance space of 1,5 m minimum is guaranteed around each vessel.
The inspection intervals shall not exceed 3 years for auxiliary equipment of vessels containing LNG.	**Verified**	Inspections requirements during operations are applied according to the local regulation.
The periodic inspection of equipment covers at least:		
- safety devices against overpressure;	**Verified**	Inspections requirements during operations are applied according to the local regulation.
- safety shut-off devices;	**Verified**	Inspections requirements during operations are applied according to the local regulation.
- safety fittings;	**Verified**	Inspections requirements during operations are applied according to the local regulation.
- gauges;	**Verified**	Inspections requirements during operations are applied according to the local regulation.
- controlling devices.	**Verified**	Inspections requirements during operations are applied according to the local regulation.

6.8 - Personnel

	Compliance verification	**NOTES**
Personnel operating the installation shall have required competency. In particular they shall be familiar with the handling of liquefied and gaseous natural gas.	**Verified**	Specific training for plant operators is foreseen before and during commissioning.
The required competency is defined in the safety plan.	**Verified**	Specific training for plant operators is foreseen before and during commissioning.
Training shall be conducted upon employment and periodically thereafter.	**Verified**	Specific training for plant operators is foreseen before and during commissioning.
Non-operating personnel shall have an appropriate training induction.	**Verified**	Specific training for plant operators is foreseen before and during commissioning.

7 – DESIGN OF VESSEL

7.1 – General

	Compliance verification	**NOTES**
Cryogenic vessels for LNG shall be designed in accordance with relevant standards or codes.	**Verified**	Confirmed. LNG tanks are designed according to EN13458 (Ref. [1]).
Annex C provides some examples of the design concepts of storage pressure vessels. Other concepts such as atmospheric vessels are not illustrated in this annex because they are not used generally for small LNG capacity storage for economical reasons. However, they are not excluded from this standard.	**Verified**	LNG storage tanks are vertical type, with 200 m^3 capacity, vacuum insulated and installed in a concrete basin. The evaporation rate foreseen is included within the range 0,1-0,2 %/day.

7.2 – Insulation

	Compliance verification	**NOTES**
Materials used for thermal insulation defined in EN 1160:1996 shall be used.	**Verified**	Confirmed. The following materials are used: - perlite for vacuum insulated vessels and piping; - glass wool or rock wool for warm and cold insulation.
The outer envelope of the vessel which is exposed to the atmosphere (metallic or concrete) shall be designed to prevent penetration of surface water or atmospheric humidity. Humidity could introduce some corrosion problems, deterioration of the insulation and of the concrete.	**Verified**	LNG tanks are vacuum insulated type. The outer jacket is completely welded and tight.

7.3 – Foundations

	Compliance verification	**NOTES**
Foundations shall be designed in accordance with recognized civil engineering practice including provisions for seismic loading if recommended. Foundation design shall take into account LNG spillage, fire and the associated possible duration of the spillage and fire.	**Verified**	Foundation are design for LNG spillage and fire exposure as indicated in Doc. no. 422REZH030001001PLY001.
Freezing due to LNG of the soil supporting the vessel shall be avoided in normal conditions. For underground vessels, soil temperature measuring devices and underground heaters may be recommended.	**Verified**	Above ground vessel, located in open area, installed on legs. A freezing condition of the soil is not possible, since there is no heat transferring from inner vessel to outer jacket and legs.

7.4 – Instrumentation

	Compliance verification	**NOTES**
Sufficient instrumentation is required to enable the vessel to be commissioned, operated and decommissioned in a safe manner. Instrumentation shall include at least the following measurements:		
- liquid level. The vessel shall be equipped with two independent systems, one with a continuous indication;	**Verified**	Confirmed provision of two independent level transmitters (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
- pressure. A pressure gauge connected above the maximum liquid level shall give a continuous indication.	**Verified**	Confirmed provision of pressure transmitter with local indication connected on inner vessel top. (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
The insulating space of the vessel may be equipped with temperature gauges, for instance in the case of double wall flat bottom vessels.	**Not applicable**	Not applicable for vacuum insulated vessels.
The following arrangements shall be ensured:		

	Compliance verification	NOTES
- in general, maintenance of instruments shall be possible during normal operation of the vessel;	**Verified**	The location/installation of instrumentation is defined in order to allow maintenance operations. Each instrument is provided with a root valve. The double level transmitters and double pressure transmitters allow the maintenance keeping continuously monitored level and pressure. Double safety valves with diverter are installed to keep always protected the tank in case of safety valves maintenance.
- the designer shall avoid the need to decommission the vessel for maintenance of instruments. However, when decommissioning is required, instruments shall have sufficient redundancy;	**Verified**	Confirmed. See point above.
- threshold detectors which have a safety function (pressure, LNG level, ...) shall be independent of the measurement devices;	**Verified**	Confirmed (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
- measurements shall be transmitted to the control unit;	**Verified**	Confirmed (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
- alarms shall be transmitted directly to the operator who can be on the site or at a remote place.	**Verified**	Alarms available at local control room. Complete control system is suitable for remote connection.

7.5 – Overpressure protection

	Compliance verification	NOTES
The vapor space of the vessel shall be connected to a flare or a vent system, to safety valves and possibly rupture disc for ultimate situation, to evacuate gas discharge due to the following events:		
- evaporation due to heat input;	**Verified**	Safety valves are designed for external fire and collected to cold vent disposal system (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram.

	Compliance verification	**NOTES**
- displacement due to filling;	**Verified**	Safety valves are designed for displacement due to filling from process and collected to cold vent disposal system.
- flash at filling;	**Not applicable**	LNG stored in subcooled conditions.
- variations in atmospheric pressure;	**Not applicable**	LNG stored under pressure conditions.
- pump spill back from a submerged pump.	**Verified**	Safety valves designed for pump cooldown and collected to cold vent disposal system.
The vessel shall be equipped with at least one relief valve and a rupture disc or two relief valves. They can relieve directly to the atmosphere except when a vapor emission in an emergency case leads to an unwanted situation. In this case, the valves shall be linked to the flare or vent system. The two relief devices shall be designed taking into account a failure of one of these devices.	**Verified**	Each vessel is equipped with two (2) safety valves, and two (2) spares, separated by a diverter valve, collected to cold vent disposal system (Ref. doc. 520REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
If a rupture disc or equivalent is installed, it shall be designed in such a way that: - it can be replaced in operation; - fragments can not fall into the vessel; - fragments can not damage any other part of the vessel. Boil-off gas compressors shall stop automatically when the rupture occurs.	**Not Applicable**	No rupture disk is foreseen.

7.6 – Impounding basin

	Compliance verification	**NOTES**
Normally a vessel and its equipment are designed to avoid the complete loss of liquid in accidental situations. For instance stop valves can be welded on liquid pipes connected to a pressurized vessel as close as possible to the vessel. So the capacity of the impounding basin of a vessel, if deemed necessary, may be restricted to a small part of the vessel capacity. Otherwise, when the total loss of liquid cannot be excluded, the basin capacity shall be at least equal to the related vessel capacity if not specified in the local regulation.	**Verified**	The basin capacity is sized to contain the total liquid of one (1) tank. Emergency shut down valves on liquid outlets are installed close to the storage tanks, inside the basin, and remotely controlled by the ESD system.

	Compliance verification	**NOTES**
The basins of two vessels may be adjacent. An excavation in the ground could act as an impounding basin provided that its properties are suitable.	**Verified**	A common impounding basin is foreseen for the storage with different slopes, to facilitate the outflow of any liquid release towards the siphoned pit located at the opposite edges of the basin.
The bottom can be covered with an insulation layer or built with special materials to minimize evaporation. It shall not be covered with gravel or vegetation (refer to EN 12066). Any means for limiting evaporation and reducing the radiation rate of ignited spills may be considered.	**Verified**	The basin floor is concrete and impermeable.
Rain or fire water which could accumulate in the basin shall be removed by relevant means without transferring spilled LNG.	**Verified**	Provision of siphoned pit allowing the drainage of rainwater, without the possibility of LNG transferring towards drainage system, since, in case of LNG release, the water suddenly freezes inside the siphon.
The top level of surrounding dykes shall not be so high as to prevent fire brigade intervention and excessive vapor confinement.	**Verified**	Impounding basin wall has access ladders foreseen for monitoring/maintenance operations inside basin.

7.7 – LNG transfer

	Compliance verification	**NOTES**
LNG can be transferred out of the vessel by a pump or by increasing the pressure in the gaseous space to transfer the liquid. The increase in pressure can be obtained by vaporizing LNG through an atmospheric vaporizer.	**Verified**	LNG transferring by means of external loading pump, submerged type.

7.8 – Overflow

	Compliance verification	**NOTES**
Overflow during the filling of a vessel shall be avoided by an automatic system. Otherwise, if it is authorized by local authorities, a vessel overflow system shall be installed and sized for the maximum flow rate of the filling pumps without causing any damage to the vessel structure.	**Verified**	High High Level Alarm on storage vessel causes the closure of the valve on the vessel inlet pipe (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).
If an overflow pipe is installed, it shall cross the vessel shell at a level at least equal to the highest level alarm. An alarm shall detect the presence of liquid in the pipe.	**Verified**	Overflow pipe is installed. An overflow alarm is given by the low temperature detection installed in the overflow pipe (Ref. doc. 520 REZH700001000SRI002 (I20784) – P&I Diagram, Ref. [10]).

7.9 – Distance between vessels

	Compliance verification	**NOTES**
The minimum distance between vessels shall be determined in accordance with the safety plan if any (see clause 5).	**Verified**	Safety distances to be maintained within the plant installation (e.g. between process equipment, storage and buildings) and plant boundaries have been assessed and are shown in B and C.

8 – INSTALLATION DESIGN

8.1 – Hazardous areas and restricted access area

	Compliance verification	**NOTES**
If not given in the local regulation, a classification of hazardous areas shall be performed in accordance with EN 60079-10 and the equipment in these zones shall be selected in accordance with EN 1127-1.	**Verified**	Hazardous area classification in accordance with EN 60079-10-1 has been developed (Ref doc. 520REZH690010000PEX001 (I21005) – Plant layout with ATEX classified area, Ref. [18]).
The fencing of areas or plant, if necessary, shall be permeable to avoid gas confinement.	**Verified**	There is no provision of fence around the plant area trapping flammable gas.
Warning signs shall be installed to inform people of risks or provide instructions.	**Verified**	Training to personnel is foreseen before and during plant commissioning. Safety signs foreseen to inform people of risks or provide instructions.

8.2 – Unloading and loading areas

	Compliance verification	**NOTES**
When a loading/unloading process is complete, hoses shall be drained and depressurized prior to disconnection.	**Verified**	The hoses are drained, depressurized, and purged with nitrogen prior to disconnection (Ref. doc. GTS19/819 – Procedure for LNG truck loading, Ref. [15]).
The unloading or loading area when a temporary hose is connected shall be considered in the classification of hazardous areas.	**Verified**	Hazardous area classification for hose connection is developed, in accordance with EN 60079-10-1 (Ref doc. 520REZH690010000PEX001 (I21005) – Plant layout with ATEX classified area, Ref. [18]).
An operational instruction shall define the required safety procedures for the unloading or loading area.	**Verified**	Truck loading procedure is developed for the Project (Ref. doc. GTS19/819 – Procedure for LNG truck loading, Ref.[15]).

8.3 – Circulation and parking

	Compliance verification	**NOTES**
The plant layout shall be designed to avoid vehicle congestion. It shall provide safe access for operation, maintenance and for firefighting.	**Verified**	An internal traffic road is foreseen all around main plant area allowing safe access for operating, maintenance and emergency operation (Ref. Doc. 900REZH690001000PLY001 (I20783) – Plant layout, Ref. [14]).
The circulation and parking of vehicles within the site shall be defined in accordance with the safety plan. The design and operating procedures shall be designed to reduce or cancel the risk of a vehicle impact with a loading or unloading vehicle.	**Verified**	Circulation of trucks around the plant area and loading area has been defined. Countercurrent circulation is avoided to reduce the risk of vehicles impact (Ref. Doc. 900REZH690001000PLY001 (I20783) – Plant layout, Ref. [14]).
Measures and protection shall be taken to avoid vehicle impacts of storage vessels.	**Verified**	Storage tanks are installed in concrete impounding basin within the process area and separated from truck loading area and roads (Ref. Doc. 900REZH690001000PLY001 (I20783) – Plant layout, Ref. [14]).
The lighting of the systems for loading and unloading shall be sufficient to ensure the safety of these operations.	**Verified**	The lighting systems foreseen in loading area is according to local regulation.

8.4 – Location of facilities

	Compliance verification	**NOTES**
Separation distances shall take into account as a minimum: - radiation flux levels; - lower flammability limit contours; - noise; - blast effects.	**Verified**	Safety distances to be maintained within the plant installation (e.g. between process equipment, storage and buildings) and plant boundaries have been assessed and are shown in Annex B and C. The main distances, relevant to the most critical equipment/area are listed hereinafter: - The liquefaction area is located at least 19 m away from the storage tanks; - the tanks are placed at over 10 m from the tanker loading area, a concrete fire-resistant wall is foreseen between the two areas to avoid mutual interactions - The LCR (Local Control Room) is located at 20 m distance from the nearest process area, to prevent it from being reached by the profile of concentration relative to the LFL. - The driver's container is located at 17 m distance from the nearest process area, to prevent it from being reached by the profile of concentration relative to the LFL. The recycle compressor and turbine/booster are located inside a building equipped with appropriate sound insulation. Sound-absorbing panel will be installed around NG and BOG compressors.
A place for safety control shall be located outside the hazardous area. The occupants shall be protected to allow sufficient time to operate emergency procedures and to leave.	**Verified**	According to Annex B results, the Local Control Room is located at a safe distance from the operational areas with presence of flammable fluids under pressure.
The air intake of possible diesel driven fire water-pumps and electric generators shall be located outside the flammable cloud envelope.	**Verified**	Air intake of diesel generators is in safe location. The fire water pumps are outside the LNG liquefaction Plant area.

8.5 – Lightning and earthing

	Compliance verification	**NOTES**
Facilities shall be protected against lightning.	**Verified**	Lightning protection is designed according to local regulation.
For potential equilibrium, all metal structures, including vessel product delivery/collection vehicles, shall be electrically bonded to a common earth.	**Verified**	All metal structures are grounded. The grounding of truck during the loading is foreseen as a mandatory procedure step to be confirmed by the operator in order to proceed with the truck loading procedure (Ref. doc. GTS19/819 - Procedure for LNG truck loading, Ref. [15]).
Major items of equipment such as vessels and vent stacks shall be bonded directly to the earth point and not rely upon the piping conductivity.	**Verified**	All major equipment are directly grounded.

ANNEX B - ACCIDENTAL SCENARIOS ANALYSIS

The purpose of the present ANNEX B is to present the results of the accidental scenarios analysis, conducted according to the safety criteria included in Ref. [1], for the LNG Liquefaction Plant Project.

The study aims to verify the plant layout configuration in terms of minimum safety distances to be maintained between plant installations and with respect to plant boundaries, and illustrating the safety measures in place.

B.1 ACCIDENTAL SCENARIO ASSESSMENT METHODOLOGY

This chapter illustrates the methodology used in the analysis. In particular, the main steps are shown in the following:

- Hazard identification: identification of loss of containment events and associated Top Events;
- Frequencies analysis: determination of release frequency;
- Event tree analysis: evaluation of hazardous scenarios frequency;
- Consequences analysis: assessment of fire, explosion and toxic consequences related to the identified hazardous scenarios;
- Preventive and mitigative measures identification.

B.1.1 Definitions

As Low As Reasonably Practicable (ALARP)	ALARP attempts to reduce the potential risk of harm as far as possible. The principle is that the residual risk shall be reduced as far as reasonably practicable.
Pasquilll Class	Category used to define atmospheric turbulence. The atmospheric turbulence is divided into six categories of stability called A, B, C, D, E and F (Pasquill classes), where the category A is the most unstable and category F identifies the most stable (or less turbulent).
Explosion	A sudden release of energy, resulting from the ignition of a congested flammable cloud (flammable vapour/gas mixed with air) in which the flames accelerate to velocities resulting in shock-wave propagation in atmosphere.
Flash fire	Unexpected fire caused by a delayed ignition of a flammable gas cloud. It is characterised by very short duration and rapidly flame front moving.
Jet fire	Turbulent flame diffusion, resulting from the combustion of a continuously released flammable substance with a significant momentum in a particular direction. Jet fires can arise from releases of gaseous and flashing liquid (two phase).
Pool fire	Turbulent diffusion fire burning above a horizontal pool of vaporizing hydrocarbons.
LNG Truck	Cryogenic road tank vehicle used for LNG transport.
Explosive zone mass	Mass of flammable substance at a concentration between the lower and the upper limit of explosivity in the cloud.
Top event	Initiating event, which is an unwanted event that leads to an accidental release scenario.

B.1.2 Hazard Identification

The first step of the analysis is to identify credible initiating events that can lead to the following final accidental scenarios:

- Fires;
- Explosions;
- Dispersions of flammable gases.

The events that could determine accidental product releases were therefore considered in the study.

In addition, for accidental flammable fluid releases assessed in the study, potential scenario escalation on other plant equipment / infrastructures is also evaluated.

B.1.2.1 Identification of congested areas

Explosions may occur when a flammable gas cloud (as a result of leaks within the area itself or adjacent areas) is entrapped inside congested areas and in presence of an ignition source.
Hence the first step of the analysis is focused on the evaluation of the flammable gas cloud extension: the contour of interest corresponds to the Lower Explosive Limit (LEL).
The characterisation of congested areas is developed on the basis of the available Project layout: all areas characterized by the presence of ignition sources and obstacles are assumed as potential congested areas. In fact, in case of accumulation of flammable mixtures, explosions are more likely to occur in plant areas where there is a high degree of congestion due to the increased levels of turbulence caused by obstacles. Consequently, flame velocity increases resulting into generation of high overpressures.

B.1.2.2 Weather Conditions

The following average weather data are considered in the present study:

- Temperature: 7.5 ºC
- Relative humidity: 60%
- Solar radiation: 1 kW/m^2

For the analysis of the accidental scenarios, in particular flammable cloud dispersion, two Pasquill stability class are considered: 2F (very stable atmosphere with wind speed of 2 m/s) and 5D (neutral atmosphere with wind speed of 5 m/s).
The same probability of occurrence between Pasquill class 2F and 5D is assumed (50% - 50%).

B.1.3 Frequency Evaluation

The methodology followed for the evaluation of the frequency of accidental scenarios is summarized in the following steps:

- Evaluation of the release frequency associated to each Top Event;
- Evaluation of the frequency of the final accidental scenarios, through the development of the Event Tree Analysis (ETA);
- Definition of the criteria for plausible scenarios' selection.

B.1.3.1 Release frequency assessment

The frequency of occurrence of the initiating events (Top Events) is determined based on the historical data analysis, relevant to the process equipment failure (i.e. top event cause), available on literature.

B.1.3.2 Frequency Assessment of Accidental Scenarios by Event Tree Analysis

Starting from the frequency of occurrence of the initiating event, described in the previous paragraph, the frequency of each specific accidental scenario (pool fire, jet fire, flash fire, explosion, dispersion) is calculated by the by means of an ETA (Event Tree Analysis) adopting, for ignition probabilities, the values reported in the international literature.

B.1.3.3 Event tree

An event tree is a visual representation of all events that can occur in a plant during an incidental sequence. The starting point ("top event") is the undesired initiating event, for example a flammable substance release or the catastrophic rupture of equipment. The "trees" show the sequences of events considering an immediate or delayed ignition of the substance release: any possible final scenario is quantified on a probabilistic basis.
Each tree branch represents a separate incident sequence (i.e., a defined set of functional relationships between the initiating event and consequent incidental scenarios).
Mitigation measures and the likelihood of success or failure are not conservatively considered. The following Figure 1-1 shows an example of event tree.

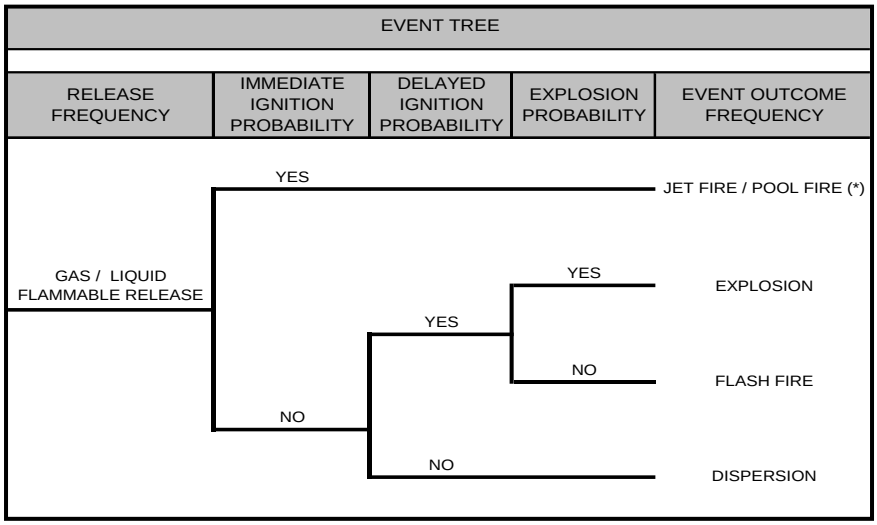


Figure 1-1 – Examples of event tree.

B.1.3.4 Ignition probability

Given the limited LNG-specific data in the literature, the ignition probabilities assessment has been conducted considering the most consolidated data for LPG systems (liquefied gas under pressure).
In particular, the ignition probability reported in Ref. [3] for flammable gases, vapours or liquids releases which are significantly above their boiling point in plants with extension area above 1200 m^2 (scenario 8 - Large Plant Gas LPG, Ref. [3]), have been used in the study.
Table 1-1 (Ref. [3]), shows the total ignition probability, sum of the immediate and delayed ignition probabilities, function of the discharge rate of flammable substance.

Scenario No. 8 - Large Plant Gas LPG (Gas or LPG release from large onshore plant)	
Releases of flammable gases, vapor or liquids significantly above their normal (NAP) boiling point from large onshore outdoor plants (plant area above 1200 m^2, site area above 35,000 m^2).	
Release rate [kg/s]	Ignition Probability
0,1	0,0011
0,2	0,0014
0,5	0,0020
1	0,0025
2	0,0050
5	0,0125
10	0,0250
20	0,0500

50	0,1250
100	0,2500
200	0,5000
500	0,6500
1000	0,6500

Table 1-1 - Ignition probability for LPG Plant Ref [3].

The representation of data reported in Table 1-1 is shown in Figure 1-2 (black curve, No. 8).

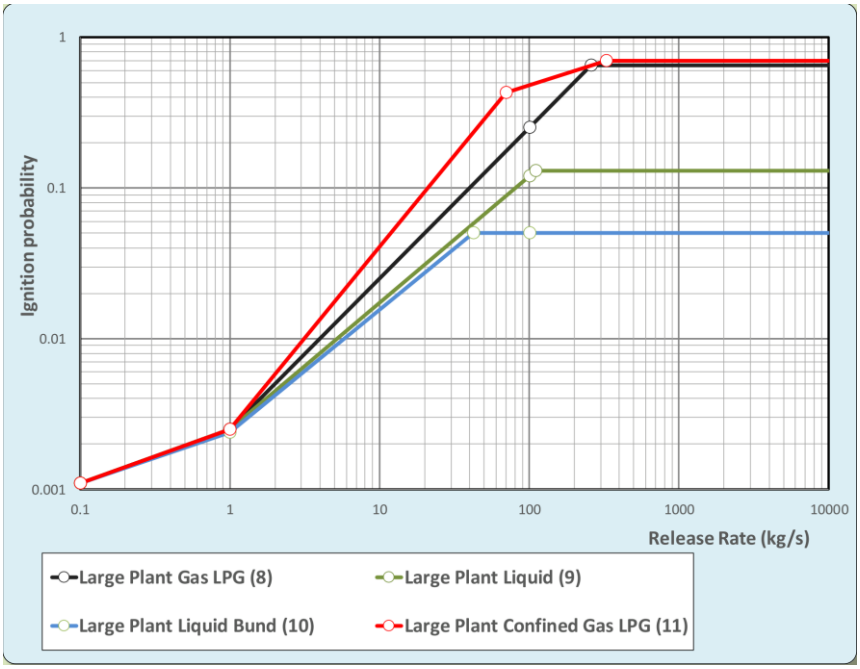


Figure 1-2 – Ignition probability for LPG Plant Ref. [3].

The distribution between immediate/delayed ignition probability has been set 50-50% each, for the purposes of the present analysis; therefore, for the development of the event trees, the total probability shown in the table is divided as follows:

$$\begin{cases} P_{tot} = P_{imm} + P_{rit} \\ P_{imm} = P_{rit} = 1/2 P_{tot} \end{cases}$$

In case of delayed ignition, the credibility for a VCE scenario is only considered whether flammable gas dispersion simulations show that the flammable cloud is able to reach any congested area.
The following probability distribution among flash fire and VCE has been assumed:

- Flash fire probability equal to 60%;
- Explosion probability equal to 40%.

In case no congested area is reached by the flammable gas cloud, flash fire probability has been set as equal to 100%.

B.1.3.5 Criteria for Selecting Credible Scenarios

As commonly internationally adopted, an accidental scenario is deemed credible when its frequency of occurrence is estimated greater than 1.00 E-06 events/year; the cited value represents the threshold value separating credible and non-credible events.

Therefore, following the Event Tree analysis, each scenario with a frequency of occurrence lower than 1.00 E-06 events /year is not further analysed in the present study.

B.1.4 Consequences Analysis

The consequences analysis is carried out for those hazardous events which may potentially occur due to accidental flammable fluid releases from process equipment. Type and magnitude of the final scenarios, depends on the following characteristics:

- Type of substance released;
- Process conditions (P, T);
- Point of release and area of substance spread;
- Confinement degree (presence of congested area);
- Possible presence of ignition source;
- Weather conditions.

The release scenarios were modelled based on normal operating conditions according to available Project documentation (Ref. [10] and [12]).

Consequences modelling has been carried out by means of Phast software, developed by DNV (Ref. [21]). Considering the software's international reputation, the obtained results are considered consistent.

B.1.4.1 Determination of the release direction

An accidental release can occur in different direction (e.g. vertical, horizontal or with a certain angle with respect to horizontal) depending on the position and geometry of the damaged equipment and the cause of the loss of containment.
To conservatively assess consequences of accidental scenarios, a horizontal release direction is assumed in the analysis.

B.1.4.2 Calculation release flow rate

The peak flowrate is determined through the PHAST software based on features listed above.
The maximum release flowrate is used in the development of the event trees (i.e. determination of ignition probabilities) and to estimate final scenario consequences.

B.1.4.3 Threshold values for assessing damage distances

The consequence analysis results are presented in tables showing, for each final event analysed (fires, explosions and dispersions), the downwind distances at which the threshold levels (expressed in terms of heat radiation, overpressure and dangerous concentrations) are reached.

B.1.4.4 Fire scenarios

The radiation threshold values considered in the analysis, in accordance with Ref. [1], are the following:

Final accidental scenarios	**Concrete surface storage vessels**	**Outer surfaces of pressure storage vessels and process facilities**	**Control room, maintenance workshops, laboratories, warehouses, etc.**	**Administrative building**
Fire (thermal radiation flux)	32 kW/m^2	15 kW/m^2	8 kW/m^2	5 kW/m^2

Table 1-2 – Threshold values for fire scenario event to be considered within the plant boundaries, Ref.[1].

Final accidental scenarios	Isolated area: area only occasionally occupied by a reduced number of persons, e.g. farmland	Intermediate area: area which is neither isolated nor critical. This is the general case	Critical area: place difficult or dangerous to evacuate quickly (e.g. sports stadium, play ground, etc.) or area where public circulation cannot be prohibited during emergencies.
Fire	13 kW/m^2	5 kW/m^2	1.5 kW/m^2

Table 1-3 - Threshold values for fire scenario event to be considered outside the plant boundaries, Ref. [1].

B.1.4.5 Flammable gas dispersion

The reference threshold value considered in the analysis for flammable gas cloud dispersion modelling is the Lower Explosive Limit (LEL), in accordance with Ref. [1]. Therefore, flammable gas concentrations equal to or higher than LEL are assumed able to originate hazardous events in presence of an adequate source of ignition.

The cloud could generate a flash fire in case of delayed ignition and no confinement or it could lead to an explosion in case the cloud is partially entrapped when ignited.

B.1.4.6 Modelling of explosions

The overpressure threshold values considered in the analysis have been derived by International standards, Ref. [7] and [8], and are shown the following Table 1-4 and Table 1-5:

Final accidental scenarios	Process equipment damage	Effects on steel frame buildings (structural damage)	Effects on concrete buildings (structural damage)
VCE (peak side-on overpressure)	0.3 bar (Ref. [7])	0.21 bar (Ref. [7])	0.14 bar (Ref. [7])

Table 1-4 – Threshold values for VCE scenario with respect to equipment and structure.

Final accidental scenarios	Effects on people (possible deaths of person)	Effects on people (skin laceration)
VCE (peak side-on overpressure)	0.14 bar (Ref. [8])	0.07 bar (Ref. [8])

Table 1-5 – Threshold values for VCE scenario with respect to people.

With reference to overpressure threshold levels for buildings damage, the reference value of 0.14 is conservatively used for the analysis.

B.2 RISK ASSESSMENT RESULTS

B.2.1 Hazard Identification

In order to identify credible accidental events that can lead to fire, explosion and flammable/toxic gas dispersion scenarios, only loss of containment events (random ruptures, i.e. events occurring as a consequence of unexpected ruptures or releases from piping and equipment) have been taken into account.

The hazards analysed in the present study are represented by flammable substance release scenarios deriving from credible loss of containment events. The hazards identification is carried out in two steps: the first one is the identification of the plant sections where a potential flammable substance release may occur (Refer to following Table 2-1), and the second one is the characterization of the plant sections in terms of operating conditions and inventory. In order to determine the Top Events that may occur in the LNG Liquefaction Plant Project, a systematic analysis of the Piping and Instrumentation Diagrams (P&IDs) and H&M Balances is carried out (Ref. [10] and [12]).

The analysis has identified the Top Events listed in the following Table 2-1 and the relevant distribution on the layout is shown in Figure 2-1.

Top Event	Description
1	Accidental Release from HW6000 - LNG Pre-Heater
2	Accidental Release from HW4001 - Precooler
3	Accidental Release from CB7000 – Cold Box (HX7000 - Primary Heat Exchanger)
4	Accidental Release from VT19000 / VT19001 - LNG Storage Tanks
5	Accidental Release from P19000 / P19001 - LNG Truck Loading Pumps
6	Accidental Release from LNG loading hoses
7	Accidental Release from C9100 – BOG Compressor 1st/2nd/3rd Stage
8	Accidental Release from C5500 – NG Regeneration Compressor 1st/2nd/3rd Stage
9	Accidental Release from V16200 - Heavy HC KO Drum

Table 2-1 – Top events description

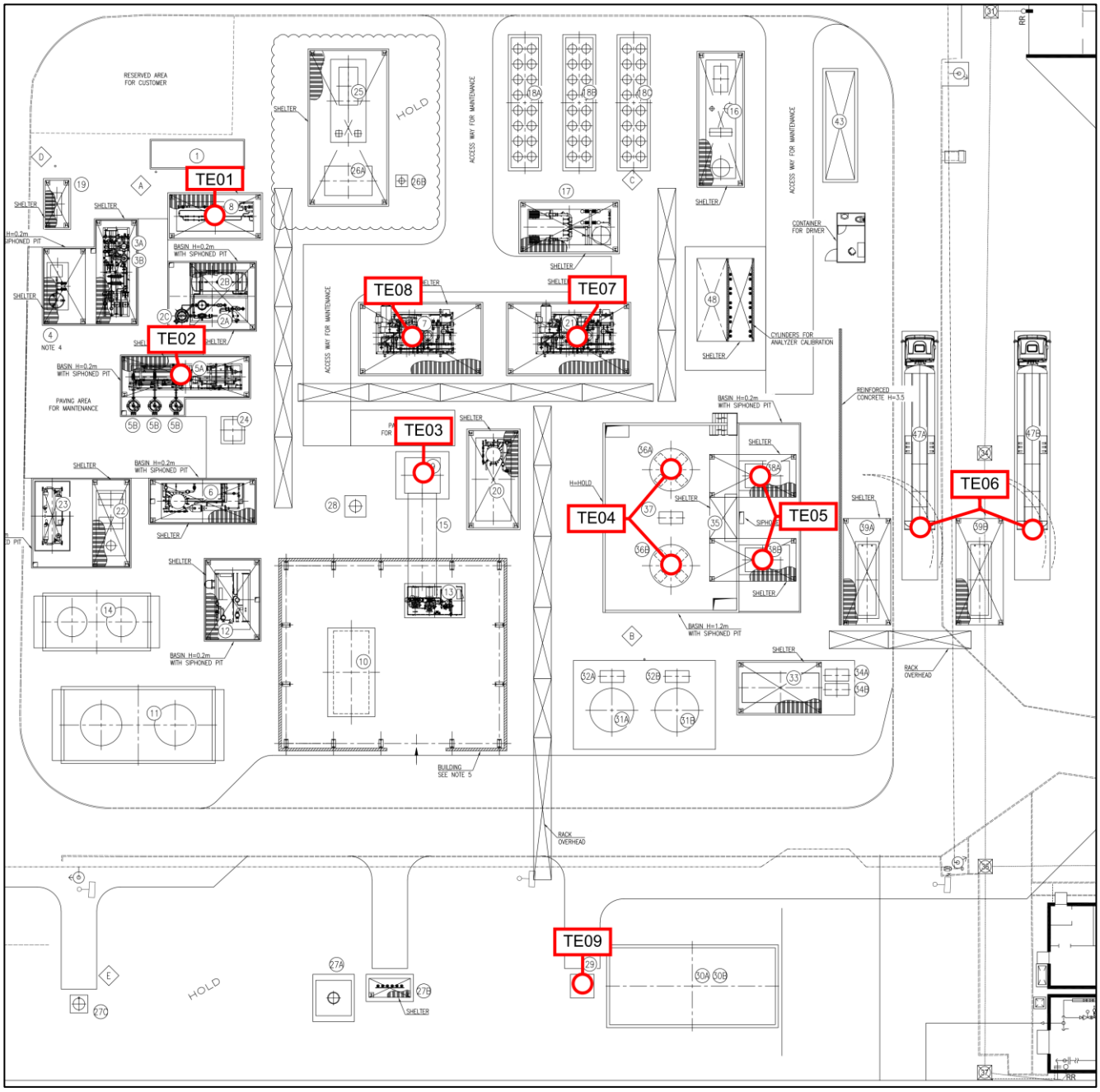


Figure 2-1 - Top events distribution on the layout

The following Table 2-2 shows the characterization of the plant's isolatable sections (i.e. portion of plant piping and equipment isolated within ESD valves), and the associated Top Events investigated in the present analysis.

Isolable Section		Equipment included in the isolatable section	Top event(s) in the isolatable section
N°	**Description**		
1	NATURAL GAS REDUCTION, GAS TREATMENT (ABSORPTION)	HW6000 - LNG PRE-HEATER RS6000 - NG REDUCTION STATION AU1000 - CO2 ABSORPTION UNIT (F1005/ S1001/TW1002)	TE.01
2	GAS TREATMENT (DEHYDRATION UNIT)	DU4000 – NATURAL GAS PRECOOLING AND DRYING UNIT (HW4001/V4003/V4004/V4005/H4006/HW4002/ F4005/S1003	TE.02

3	LIQUEFACTION	HX7000 - PRIMARY HEAT EXCHANGER HX7001 - LNG SUBCOOLER HEAT EXCHANGER S7003 - LNG SEPARATOR	TE.03
4	LNG PIPE FROM COLD BOX TO STORAGE	-	(1)
5	LNG STORAGE	VT19000 - LNG STORAGE TANK VT19001 - LNG STORAGE TANK E19000 - LNG BUILD UP VAPORIZER	TE.04
	LOADING PUMP	P19000 - LNG TRUCK LOADING PUMP P19001 - LNG TRUCK LOADING PUMP V16200 - HEAVY HC KO DRUM	TE.05
6	LOADING HOSE AND ATB	LNG LOADING HOSE AND BOIL OFF GAS EW9000 - HC HEATER	TE.06
7	BOG COMPRESSOR	ST9100 - INLET DUMPER C9100 - COMPRESSOR 1ST/2ND/3RD STAGE HW9101/9102/9103 - 1ST/2ND/3RD STAGE INTERCOOLER ST9103 - 3RD STAGE SEPARATORS	TE.07
8	NG REGENERATION COMPRESSOR	ST5500 - INLET DUMPER C5500 - COMPRESSOR 1ST/2ND/3RD STAGE HW5501/5502/5503 - 1ST/2ND/3RD STAGE INTERCOOLER ST5501/5502/5503 - 1ST/2ND/3RD STAGE SEPARATORS F5501 NG REGENERATION COMPRESSOR POST-FILTER	TE.08
9	THERMAL OXIDISER	EW9000 - HC HEATER V16200 - HEAVY HC KO DRUM SU2000 - STRIPPING UNIT (HW2004/P2005A-B/ HW2007/ TW2008/ F2002/ F2001/ F2003/ HW2010/ S2011/ HW2009/ H2001/ P2012A-B) SRU3000 - SOLVENT ADDITION AND REMOVAL UNIT	TE.09
10	NG REGENERATION	HW5000 - NG REGENERATION COOLER ST5000 - NG CONDENSATE SEPARATOR EW5000 - NG REGENERATION HEATER	(1)

Notes:
1) As a result of the systematic analysis of the Piping and Instrumentation Diagrams (P&IDs), no top event is identified for the section, in view of the process operating conditions and the limited hold-up of the isolatable section.

Table 2-2 – Isolatable sections and relevant Top Events

B.2.1.1 Identification of congested areas

The congested areas are identified in accordance with the criteria mentioned in paragraph B.1.2.1 and the relevant evaluated volume is reported in Table 2-3. The distribution of the congested area on the layout is shown in Figure 2-2.

N° congested areas	Description	Area [m^2]	Height (1) [m]	Total Volume [m^3]	Blast strength category (Ref. [6])
CA-01	Process Area (gas treatment and liquefaction area)	2020	3.5	7070	5
CA-02	LNG storage area	390	7	2730	5
CA-03	Truck loading area	370	4	1480	5

N° congested areas	Description	Area [m^2]	Height (1) [m]	Total Volume [m^3]	Blast strength category (Ref. [6])
1) The height of the congested area is evaluated considering an intermediate value among all the equipment and structures heights included in the area.					

Table 2-3 – Congested areas characterization

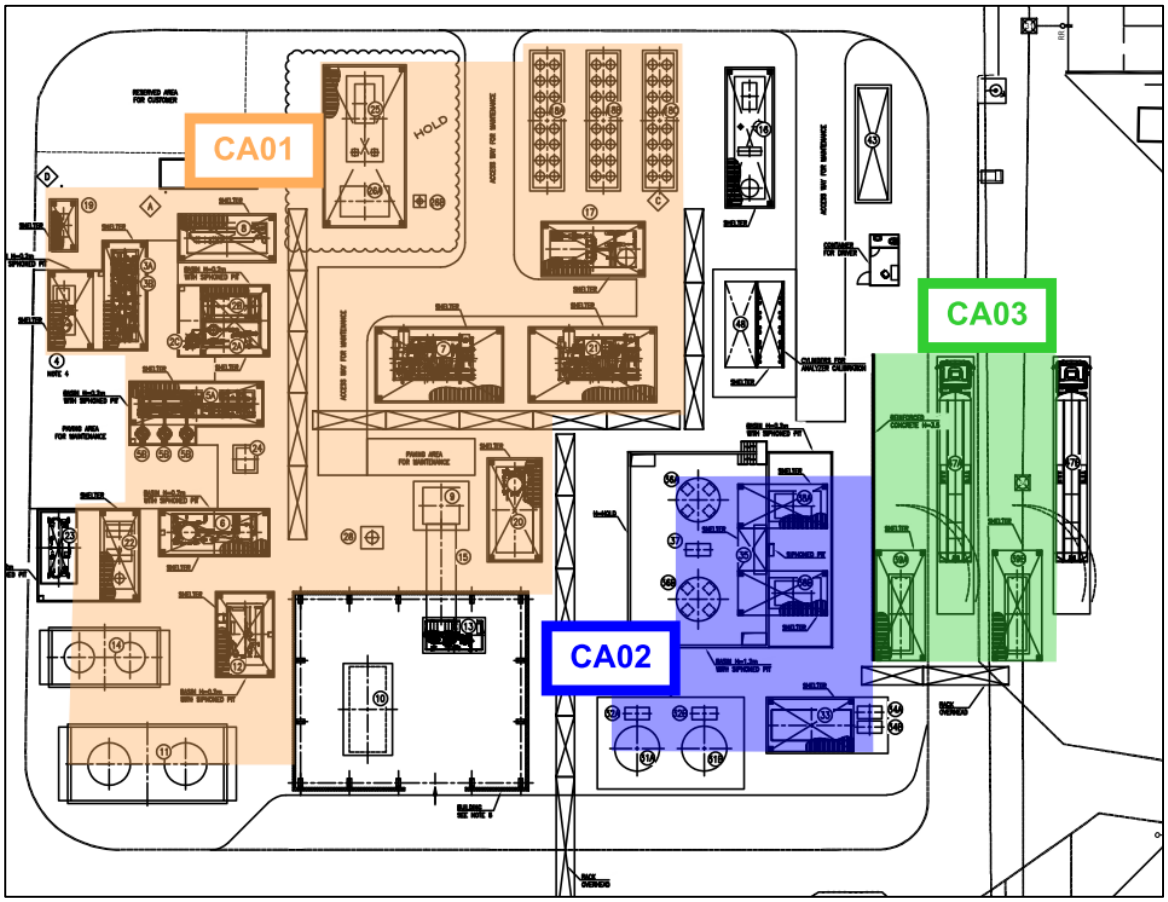


Figure 2-2 - Congested areas distribution on the layout

The explosions have been modelled using the "Multi-Energy" model. For this model it is necessary to provide the blast strength category parameter as input data. For the purpose of the present analysis, the initial blast strength category is selected using the methodology provided by Kinsella (Ref. [6]): the selection of the blast strength category is based on the obstruction degree, confinement, and ignition strength. For all the case studies the curve No. 5 is determined as the representative one.

B.2.2 Frequencies Analysis

B.2.2.1 Event release frequency assessment

As reported in paragraph B.1.3, nine (9) initiating events (Top Events) are identified for the LNG Liquefaction Plant.

The frequency of occurrence of the selected events is evaluated through the analysis of the historical data (databases available in literature) relevant to the possible causes of failure for each equipment under investigation (Ref. [2] and [4]).

In particular, for the development of the analysis, releases from small diameter holes (diameter between 1 and 10 mm) are considered. These releases, in fact, are the most frequent in Oil & Gas systems; for this reason, this range is selected as the most representative to define the minimum safety distances to be maintained within the plant and evaluate the safety measured to be in placed.

A 5mm diameter hole (intermediate value in the cited release frequency range) is chosen as representative for the calculation of the release rate and the consequence analysis.

The release frequencies determined for each Top Event are reported in the following Table 2-4.

Top Event	Description	Release Frequencies [event/y]
1	Accidental Release from HW6000 - LNG Pre-Heater	**7.70E-04**
2	Accidental Release from HW4001 - Precooler	**7.70E-04**
3	Accidental Release from CB7000 – Cold Box (HX7000 - Primary Heat Exchanger)	**9.70E-03**
4	Accidental Release from VT19000 / VT19001 - LNG Storage Tanks	**7.60E-04**
5	Accidental Release from P19000 / P19001 - LNG Truck Loading Pumps	**2.43E-03** (Refer to Table 2-5)
6	Accidental Release from LNG loading hoses	**1.75E-02** (Refer to Table 2-6)
7	Accidental Release from C9100 – BOG Compressor 1st/2nd/3rd Stage	**2.31E-02**
8	Accidental Release from C5500 – NG Regeneration Compressor 1st/2nd/3rd Stage	**2.31E-02**
9	Accidental Release from V16200 - Heavy HC KO Drum	**7.60E-04**

Table 2-4 –Overall release frequencies for each Top Event

All scenarios, excluding scenarios 5 and 6, are relevant to continuously operated equipment. While, accidental releases from LNG loading pump (Top Event 5) and LNG loading hose (Top Event 6) can occur only during the trucks loading operation.

In view of the followings:

- The maximum number of loads per day foreseen is 8;
- The duration of a single load is 1 hour;
- The loading operations are conducted every day (365 days/year);

the annual frequency for which an accidental release of LNG from the loading pump may occur is calculated as equal to 2.43 x 10-3 events/year.

Event Type	Pump release frequency (Ref. [2])	Probability of pump operation	Release frequency [event/y]
Accidental LNG release from LNG Loading Pump (P-19000/1)	7.30×10^{-3}	0.334	**2.44×10^{-3}**

Table 2-5 - Centrifugal pump release frequencies for 5 mm hole.

The annual frequency for which an accidental release of LNG from the loading hose may occur is calculated as equal to 1,75 x 10-2 events/year.

Event Type	Release frequency per operation (Ref. [4])	Number of loads per year	Release frequency [event/y]
Accidental LNG release from loading hose	6×10^{-6}	2920	**1.75×10^{-2}**

Table 2-6 - LNG loading hose release frequencies for 5 mm hole.

B.2.2.2 Final accidental scenario frequency assessment

Starting from the leak frequencies reported in paragraph B.2.2.1, the frequency of each specific final scenario (fire/explosion/cloud dispersion) is calculated by means of the Event Tree Analysis, adopting values from international literature for immediate and delayed probabilities of ignition (refer to paragraph B.1.3.4) on the basis of the maximum release flowrates (calculated as shown in paragraph B.2.3.1).

Event trees are developed for the two atmospheric stability classes 2F and 5D, for which the same probability of occurrence is assumed (50% - 50%). Hence, for each Top Event, two event tree with the same final accidental scenario frequencies are determined.
For each top event, the event trees for atmospheric stability class 2F only are presented hereinafter, and the following Table 2-7 summarizes the frequencies of occurrence for each final accidental event.

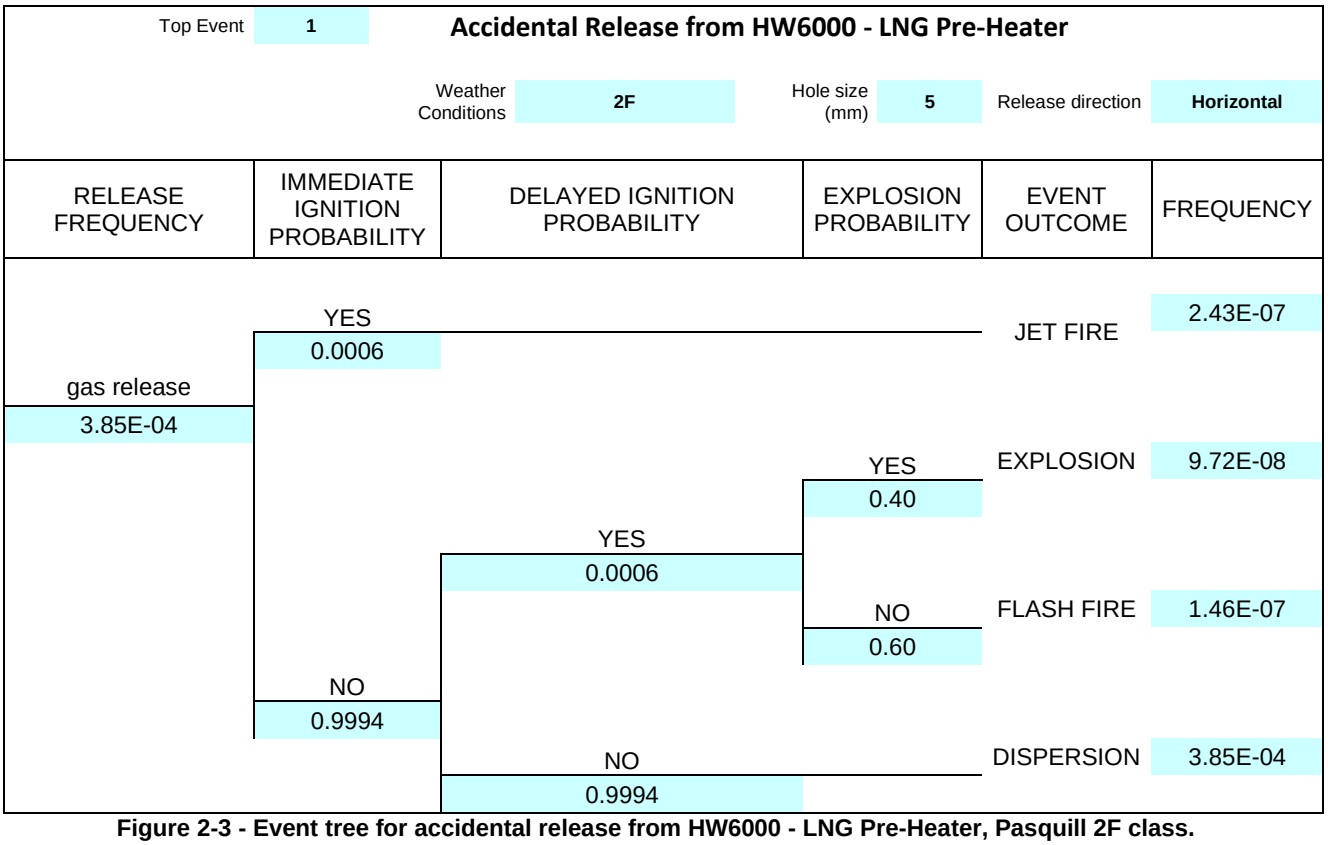


Figure 2-3 - Event tree for accidental release from HW6000 - LNG Pre-Heater, Pasquill 2F class.

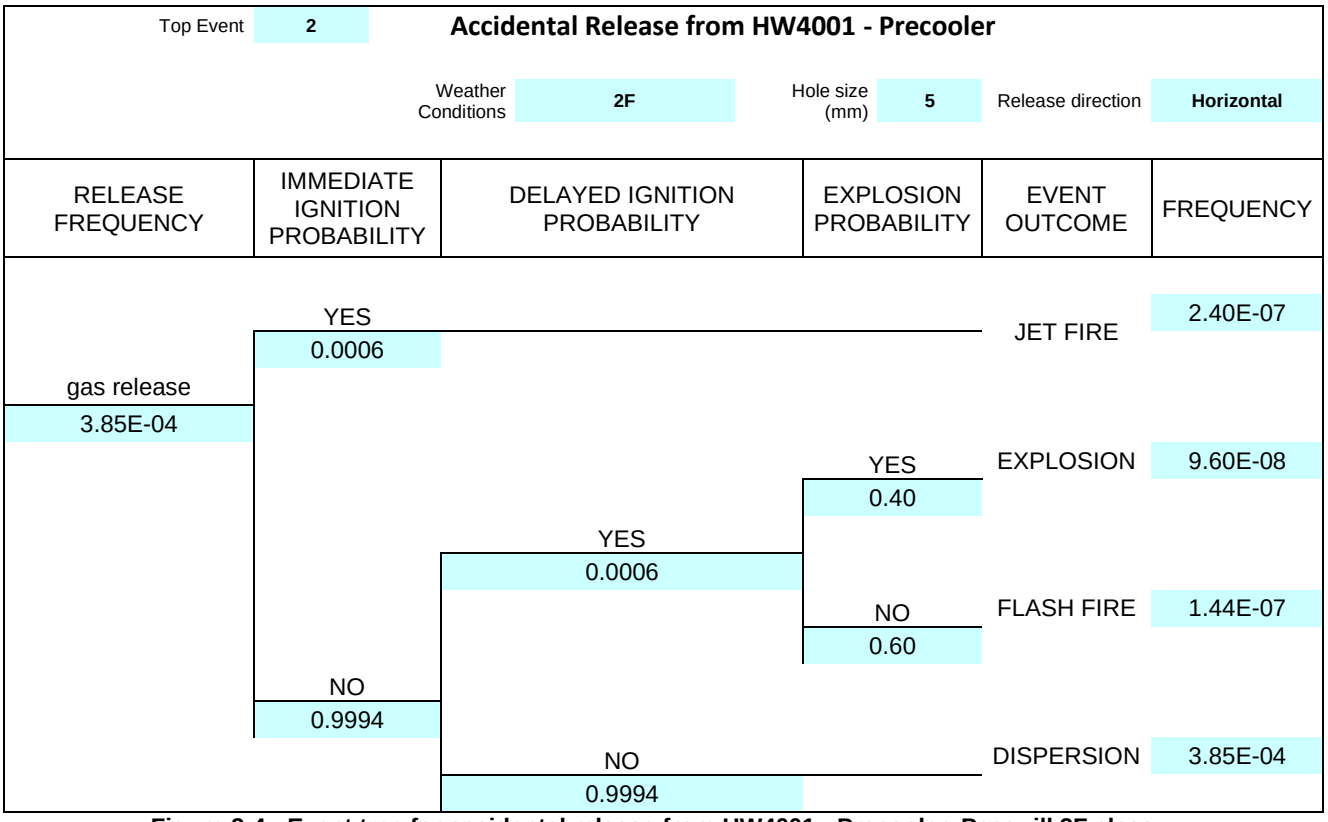


Figure 2-4 - Event tree for accidental release from HW4001 - Precooler, Pasquill 2F class.

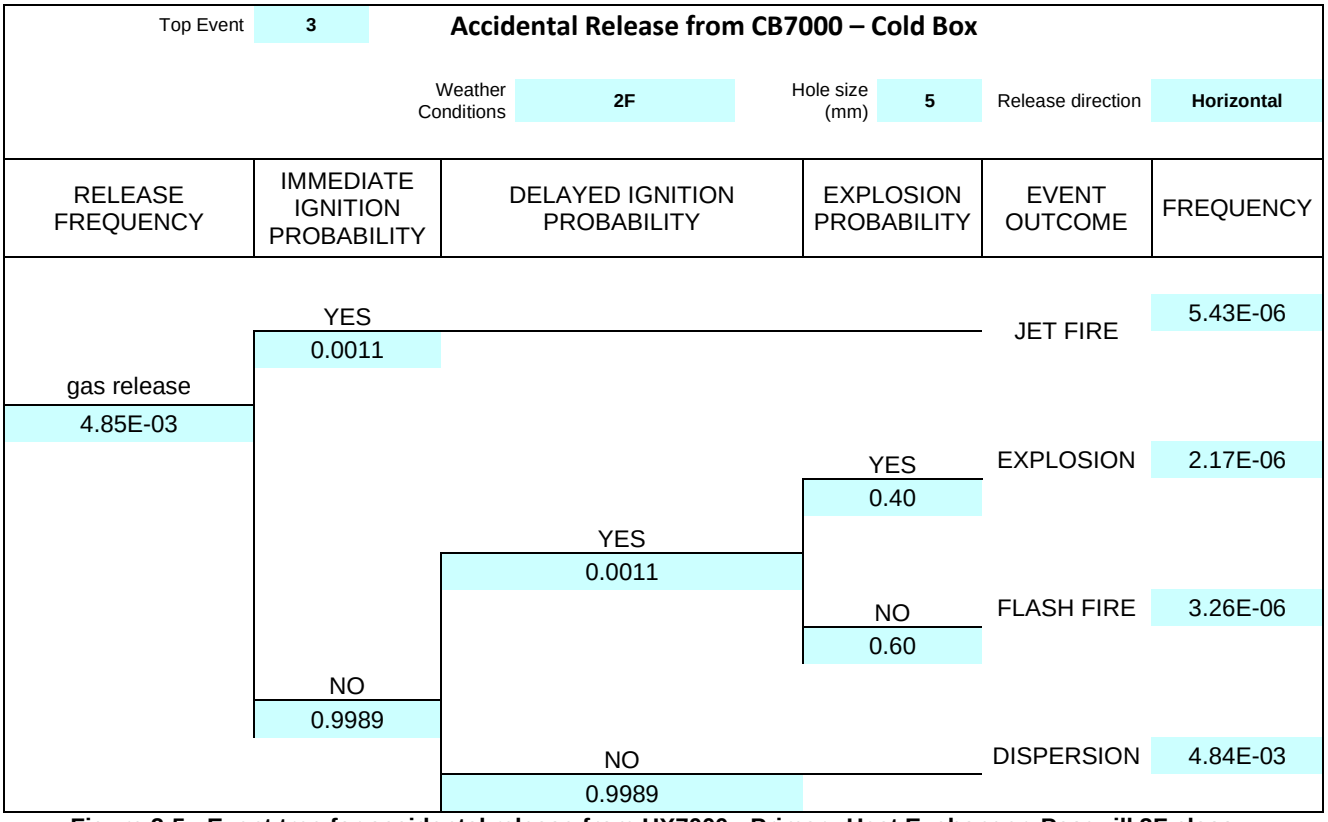


Figure 2-5 - Event tree for accidental release from HX7000 - Primary Heat Exchanger, Pasquill 2F class.

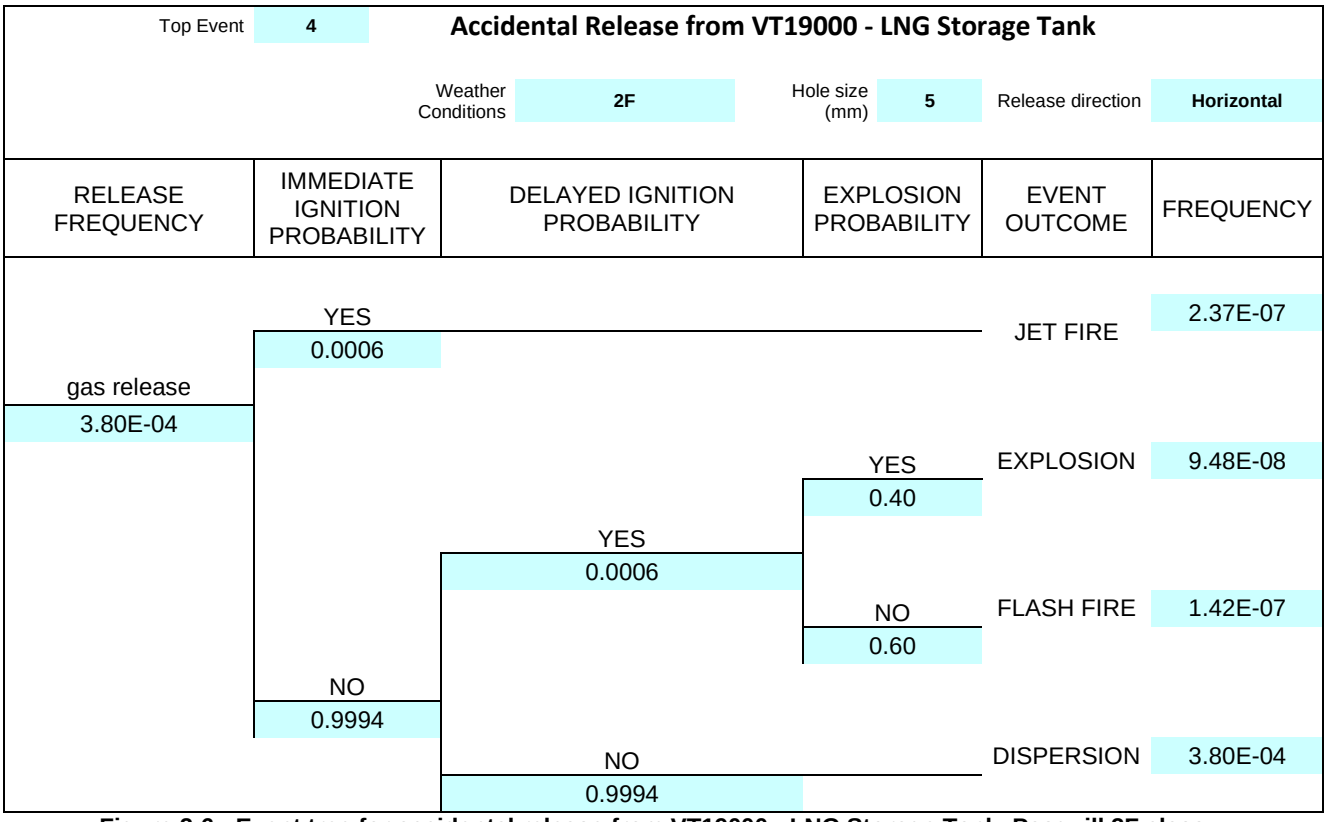


Figure 2-6 - Event tree for accidental release from VT19000 - LNG Storage Tank, Pasquill 2F class.

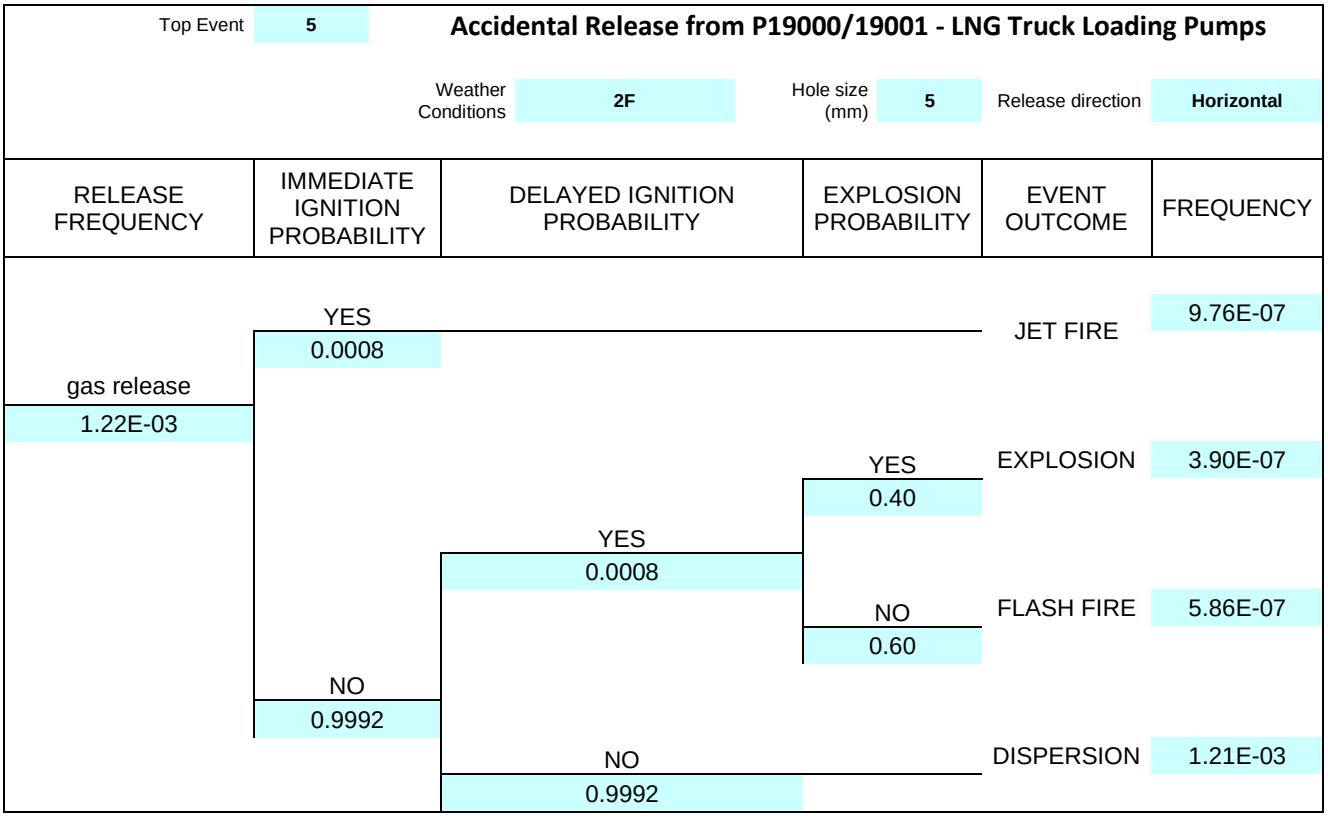


Figure 2-7 - Event tree for accidental release from P19000/19001 - LNG Truck Loading Pumps, Pasquill 2F class.

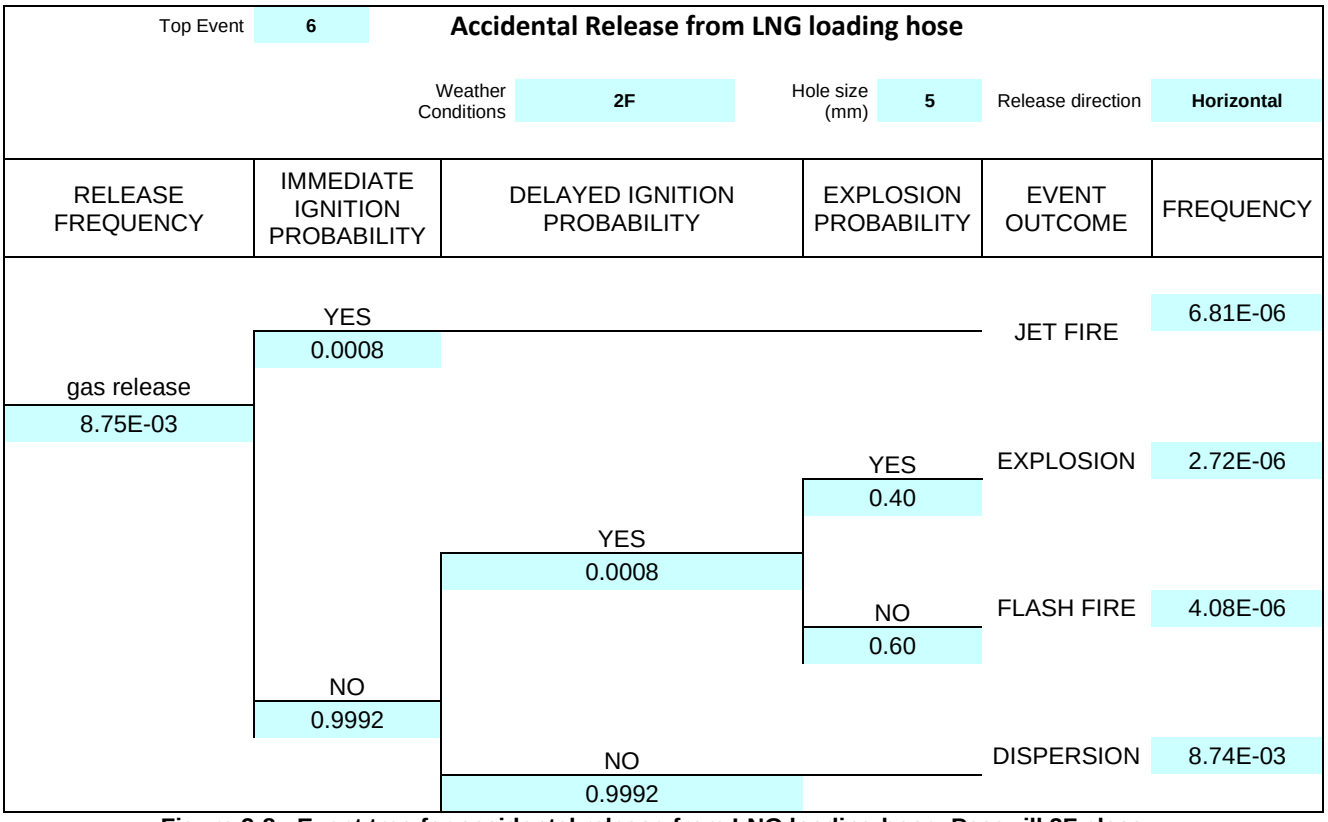


Figure 2-8 - Event tree for accidental release from LNG loading hose, Pasquill 2F class.

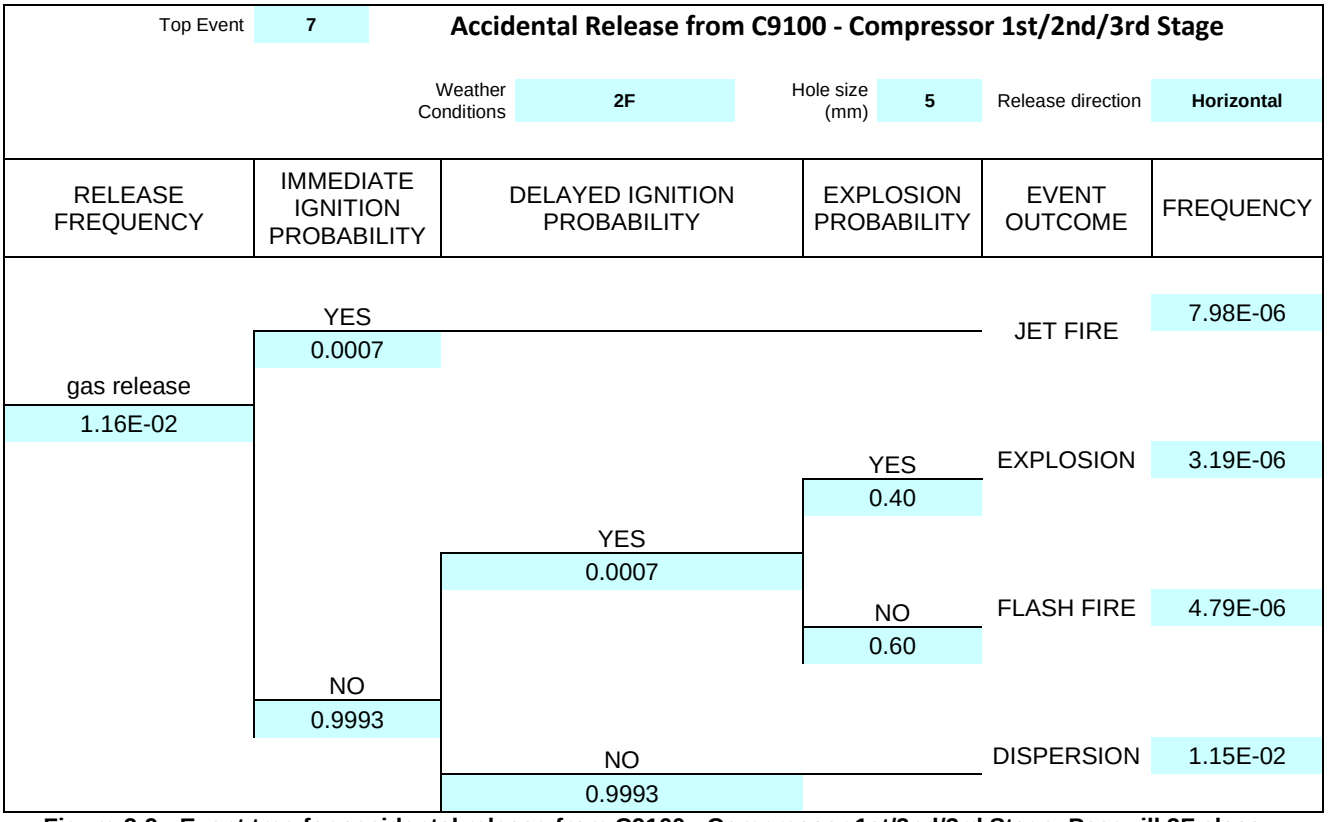


Figure 2-9 - Event tree for accidental release from C9100 - Compressor 1st/2nd/3rd Stage, Pasquill 2F class.

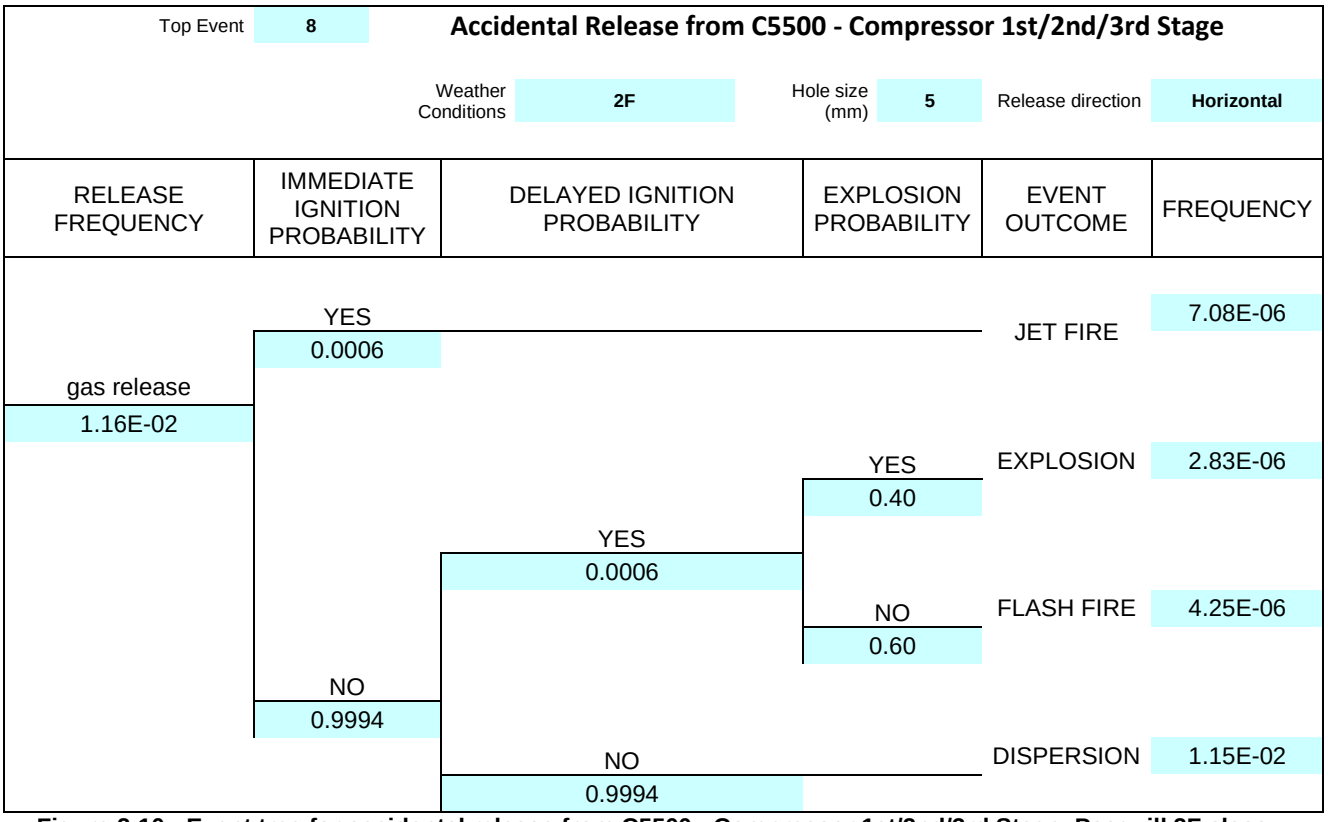


Figure 2-10 - Event tree for accidental release from C5500 - Compressor 1st/2nd/3rd Stage, Pasquill 2F class.

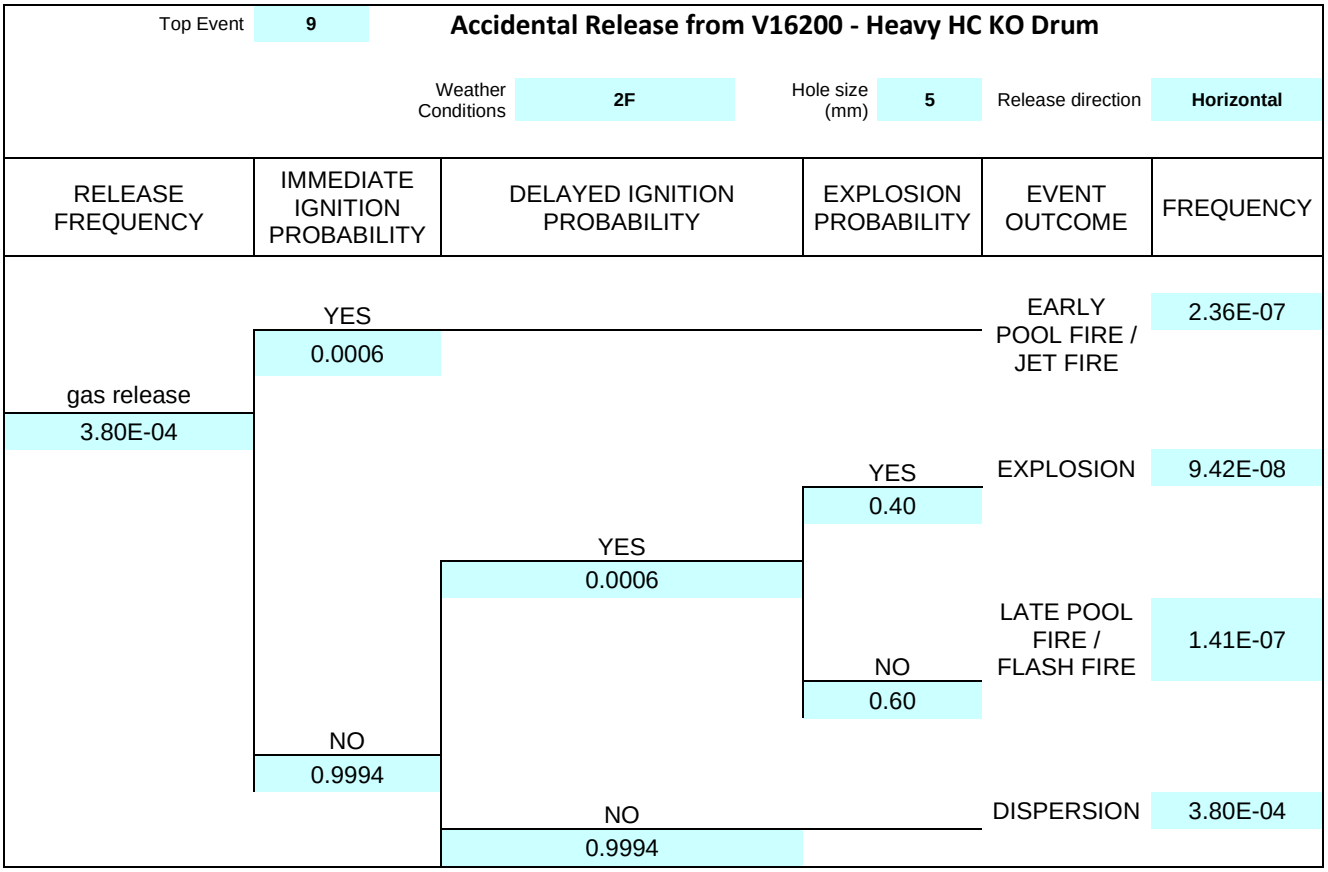


Figure 2-11 - Event tree for accidental release from V16200 - Heavy HC KO Drum, Pasquill 2F class.

Top Event	Description	Jet fire/ Immediate Pool Fire Frequency [event/y]			Flash Fire/ Late Pool Fire Frequency [event/y]			Explosion Frequency [event/y]			Dispersion Frequency [event/y]		
		Total	2F	5D	Total	2F	5D	Total	2F	5D	Total	2F	5D
1	Accidental Release from HW6000 - LNG Pre-Heater	4.86E-07	2.43E-07	2.43E-07	2.92E-07	1.46E-07	1.46E-07	1.94E-07	9.72E-08	9.72E-08	7.69E-04	3.85E-04	3.85E-04
2	Accidental Release from HW4001 - Precooler	4.80E-07	2.40E-07	2.40E-07	2.88E-07	1.44E-07	1.44E-07	1.92E-07	9.60E-08	9.60E-08	7.69E-04	3.85E-04	3.85E-04
3	Accidental Release from CB7000 – Cold Box (HX7000 - Primary Heat Exchanger)	1.09E-05	5.43E-06	5.43E-06	6.51E-06	3.26E-06	3.26E-06	4.34E-06	2.17E-06	2.17E-06	9.68E-03	4.84E-03	4.84E-03
4	Accidental Release from VT19000 / VT19001 - LNG Storage Tanks	4.74E-07	2.37E-07	2.37E-07	2.85E-07	1.42E-07	1.42E-07	1.90E-07	9.48E-08	9.48E-08	7.59E-04	3.80E-04	3.80E-04
5	Accidental Release from P19000 / P19001 - LNG Truck Loading Pumps	1.95E-06	9.76E-07	9.76E-07	1.17E-06	5.86E-07	5.86E-07	7.81E-07	3.90E-07	3.90E-07	2.43E-03	1.21E-03	1.21E-03
6	Accidental Release from LNG loading hoses	1.36E-05	6.81E-06	6.81E-06	8.17E-06	4.08E-06	4.08E-06	5.44E-06	2.72E-06	2.72E-06	1.75E-02	8.74E-03	8.74E-03
7	Accidental Release from C9100 – BOG Compressor 1st/2nd/3rd Stage	1.60E-05	7.98E-06	7.98E-06	9.58E-06	4.79E-06	4.79E-06	6.38E-06	3.19E-06	3.19E-06	2.31E-02	1.15E-02	1.15E-02
8	Accidental Release from C5500 - NG Regeneration Compressor 1st/2nd/3rd Stage	1.42E-05	7.08E-06	7.08E-06	8.49E-06	4.25E-06	4.25E-06	5.66E-06	2.83E-06	2.83E-06	2.31E-02	1.15E-02	1.15E-02
9	Accidental Release from V16200 - Heavy HC KO Drum	4.71E-07	2.36E-07	2.36E-07	2.83E-07	1.41E-07	1.41E-07	1.88E-07	9.42E-08	9.42E-08	7.59E-04	3.80E-04	3.80E-04

Table 2-7 – Frequencies summary of final accidental scenario

With reference to the event frequencies determined above, the main findings are listed hereinafter:

- All the final scenarios (fire/explosion/cloud dispersion) determined by a natural gas accidental release from the cold box - CB7000, from the LNG loading hoses, from the NG compressor – C9100 and from the BOG compressor – C5500 (top events 3, 6, 7 and 8) are considered as “credible”, since characterized by a frequency of occurrence higher at 1E-06 events/year;
- As regards to an LNG accidental release from the truck loading pumps - P19000/ P19001 (top event 5), the jet and flash fires are characterized by a frequency of occurrence greater than 1E-06 events/year and are therefore considered as “credible”. The explosion event, on the other hand, is characterized by a frequency of occurrence lower than 1E-06 events/year; for this reason, since deemed as "not credible" the consequences of this scenario can be considered not relevant for the study and are not further analysed;
- With respect to the following accidental releases:
    - Release of natural gas from the LNG Pre-Heater - HW6000, from the Pre-Cooler – HW4001 (top events 1 and 2);
    - Release of LNG from the LNG storage tank – VT19000 (Top Event 4);
    - Release of heavy hydrocarbons from the KO Drum – V16200 (top event 9);

  all the final events (except for atmospheric neutral gas dispersion without ignition, which does not represent a critical event) are characterized by a frequency of occurrence lower than 1E-06 events/year, therefore they are considered as "not credible".

In the next section, the consequence analysis is developed exclusively for the scenarios identified as “credible”.

B.2.3 Consequences Analysis

The final scenarios identified in the Event Trees Analysis, shown in the previous paragraph, are analysed by means of PHAST software (Ref. [21]).
The downwind distances at which the threshold levels are reached, shown in the following chapters, are assessed at 1 m height above ground level.

B.2.3.1 Mass flow rate Calculation

Table 2-8 shows the operating conditions and release characteristics relevant to each accidental scenario investigated.

Properties	**Top Events**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Description	Accidental Release from HW6000 - LNG Pre-Heater	Accidental Release from HW4001 - Precooler	Accidental Release from CB7000 – Cold Box (HX7000 - Primary Heat Exchanger)	Accidental Release from VT19000 - LNG Storage Tank	Accidental Release from P19000 (or P19001) - LNG Truck Loading Pump	Accidental Release from LNG loading hose	Accidental Release from C9100 - Compressor 1st/2nd/3rd Stage	Accidental Release from C5500 - Compressor 1st/2nd/3rd Stage	Accidental Release from V16200 - Heavy HC KO Drum
Fluid	Natural Gas	Natural Gas	LNG	LNG	LNG	LNG	Natural Gas	Natural Gas	Heavy Hydrocarbon
State	Gas	Gas	Liquid	Liquid	Liquid	Liquid	Gas	Gas	Gas
P op [bara]	44	43.66	43.15	2.6	7.6	6.5	44.5	44.5	1.1
T op [°C]	10	20	-168	-166.5	-166.2	-166.2	50	50	50
Hole Diameter [mm]	5	5	5	5	5	5	5	5	5
Hole ground height [m]	1	1	1	1	1	1	1	1	1
Composition (mol) (1)									
Methane	0.8650	0.8799	0.8823	0.8842	0.8842	0.8842	0.4810	0.8786	0
Ethane	0.0690	0.0701	0.0703	0.0706	0.0706	0.0706	0.0001	0.0700	0
Propane	0.0154	0.0156	0.0157	0.0158	0.0158	0.0158	0	0.0156	0
i- Butane	0.0020	0.0020	0.0021	0.0021	0.0021	0.0021	0	0.0020	0
n-Butane	0.0023	0.0023	0.0024	0.0024	0.0024	0.0024	0	0.0023	0
i- Pentane	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0	0.0005	0
N-Pentane	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0	0.0004	0
C6+	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0	0.0005	1
N_2	0.0242	0.0247	0.0247	0.0234	0.0234	0.0234	0.3951	0.0246	0
CO_2	0.0195	40 ppm	40 ppm	40 ppm	40 ppm	0	0	0	0
Hydrogen	0.0010	0.0011	0.001	0.0002	0.0002	0.0002	0.1238	0.0011	0
H_2O	0.0002	0.0028	0	0	0	0	0	0.0042	0

Note:
(1) For the purpose of accidental scenarios modelling using Phast software, the compositions shown in the following table will be conservatively normalized excluding N_2, CO_2 e H_2O.

Table 2-8 – Operating parameters and release characteristics for each top event

The following Table 2-9 shows the calculated flowrates for all the analysed Top Events. The peak release flowrates is conservatively used for consequence modelling and Event Tree Analysis shown in paragraphs B.2.3.2, B.2.3.3, B.2.3.3 and B.2.2.2.

Top Event	Peak mass flow rate [kg/s]	Total Ignition Probability (Ref. [3]) [%]
1	0.148	0.126
2	0.142	0.125
3	0.734	0.224
4	0.143	0.125
5	0.290	0.161
6	0.265	0.156
7	0.190	0.138
8	0.136	0.122
9	0.140	0.124

Table 2-9 – LNG release results from a 5mm hole size

B.2.3.2Fire Scenario Simulation

Based on modelling simulations carried out by means of Phast software, the fire scenario obtained is the jet fire. In fact, there is no pool formation on the ground that could generate a pool fire, if ignited. Table 2-10 shows the flame lengths and distances corresponding to the radiation threshold values in case of horizontal jet fire, for both Pasquill classes 2F and 5D.

Top Event	Pasquill Class	Flame length [m]	Downwind distance to heat radiation thresholds [m]				
			1,5 [kW/m^2]	5 [kW/m^2]]	8 [kW/m^2]	13 [kW/m^2]	15 [kW/m^2]
3	2F	14.7	40.7	23.3	21.0	19.1	18.7
	5D	11.4	39.0	20.8	18.3	16.4	15.9
5	2F	11.3	29.7	17.4	15.6	14.2	13.9
	5D	8.8	28.0	15.4	13.6	12.2	11.8
6	2F	11.0	28.7	16.9	15.1	13.8	13.5
	5D	8.6	27.0	14.9	13.1	11.8	11.5
7	2F	5.5	9.4	6.6	6.2	5.9	5.8
	5D	5.5	8.7	6.3	6.0	5.8	5.7
8	2F	4.6	6.9	5.2	5.0	4.8	4.8
	5D	4.6	6.4	5.1	4.9	4.7	4.7

Table 2-10 - Jet Fire simulation results for 5mm hole size release

The distances at which the threshold values of thermal radiation for jet fire scenarios are reached are mapped in Appendix C.

B.2.3.3Flammable Gas Dispersion Simulation

A dispersion analysis is performed using the Phast software to identify all the plant areas which may be affected by the presence of a flammable gas cloud. The cloud could generate a flash fire in case of delayed ignition and no confinement or it could lead to an explosion in case the cloud is partially entrapped when ignited. Flammable gas concentrations equal to or higher than LEL are assumed able to originate hazardous events in presence of an adequate source of ignition.

Flash fire is an instantaneous event; it can take just few seconds to develop. For this reason, the potential impact to assets is negligible, while the effects on people shall be considered.

The LEL distances calculated for the releases from all the identified random ruptures are listed, for Pasquill class 2F and 5D, in the following Table 2-11. Due to low temperatures, the LNG gas cloud behaves as a heavy gas, slumping and spreading on the ground, and the calculated downwind distances at reference threshold value (i.e., LEL), are reached at an elevation lower than 1 m height above the ground.
The explosive mass involved in a potential explosion is detailed in the next paragraph for those scenarios where the flammable cloud reaches a congested area, as determined in paragraph B.1.2.1.

Top Event	Pasquill Class	Downwind distance at LEL [m]
3	2F	14.3
	5D	10.1
5	2F	13.9
	5D	6.7
6	2F	13.7
	5D	6.4
7	2F	1
	5D	1
8	2F	1
	5D	1

Table 2-11 - Flash Fire simulation results for 5mm hole size release

The distances at which the flammable gas concentration threshold value for flash fire scenarios (i.e., LEL) is reached are mapped in Appendix C.

B.2.3.4 Explosion Scenario Simulation

The first step of the explosion modelling is the evaluation of the flammable gas cloud extension, whose contours correspond to LEL. For those scenarios deemed credible, the dispersion analysis results shown in paragraph B.2.3.3 are compared to the congested areas, determined in paragraph B.2.1.1, where the flammable gas cloud could remain entrapped leading to an explosion.

The explosion modelling results are identified in terms of distance to overpressure threshold levels from the boundary of the relevant Congested Area. Table 2-12 and Table 2-13 show explosion results for those Top event which may cause VCE for both the weather class 2F and 5D.

Congested Area (CA)	Top Event	Flammable mass	Distance to overpressure thresholds [m]		
		[kg]	0.3 [bar]	0.14 [bar]	0.07 [bar]
CA-01	3	0.508	Not reached	5.3	10.6
	7	0.008	Not reached	1.3	2.6
	8	0.003	Not reached	1.0	2.0
CA-03	6 (1)	0.434	Not reached	5.0	10.1

Notes:

1) For what concern TE06, even if the calculated gas cloud concentration reaches CA02, considering that the LNG gas cloud behaves as a heavy gas (slumping and spreading on the ground) and the presence of a 3.5 m height wall between pumps and loading areas, it is assumed that the wall represents a physical obstacle to the gas cloud dispersion towards the CA02, confining the cloud in CA03.

Table 2-12 - VCE simulation results for 5mm hole size release – 2F

Congested Area	Top Event	Flammable mass	Distance to overpressure thresholds [m]		
		[kg]	0.3 [bar]	0.14 [bar]	0.07 [bar]
CA-01	3	0.235	Not reached	4.1	8.2
	7	0.006	Not reached	1.2	2.4
	8	0.003	Not reached	0.9	1.8
CA-03	6 (1)	0.104	Not reached	3.1	6.3

Notes:

1) For what concern TE06, even if the calculated gas cloud concentration reaches CA02, considering that the LNG gas cloud behaves as a heavy gas (slumping and spreading on the ground) and the presence of a 3.5 m height wall between pumps and loading areas, it is assumed that the wall represents a physical obstacle to the gas cloud dispersion towards the CA02, confining the cloud in CA03.

Table 2-13 - VCE simulation results for 5mm hole size release – 5D

It has to be noticed that the determined flammable masses involved in potential VCE scenarios are limited. Nevertheless, for the sake of analysis completeness, the consequence results for explosions events are conservatively assessed as shown in tables above (without showing overpressure contours on the relevant drawings in Annex C).

B.2.4 Results of the Analysis

The purpose of the document is to present the outcomes of the accidental scenarios analysis, conducted according to the safety criteria included in Ref. [1], for the LNG Liquefaction Plant Project.

This chapter illustrates the minimum risk compensation measures foreseen, based on the results obtained in the study.

The frequency assessment presented in paragraph B.2.2.2, outlined that some final accidental scenarios (relevant to TE01, TE02, TE04 and TE09) are assessed as “not credible” and, for such events, consequence modelling has not been further analysed in the present study.

According to fire scenario simulation results for **TE03** (shown in paragraph B.2.3.2) in case of a jet fire from the cold box, the maximum calculated downwind distance corresponding to the threshold level of 15 kW/m^2 (reference threshold value for process equipment) is 19 m. The determined heat radiation contour may reach other nearby equipment belonging to other isolatable sections, nevertheless, the followings safety measures are in place to reduce the potential fire scenario effects:

- A F&G system, which automatically initiates emergency actions (ESD), is foreseen in the liquefaction area (presence of flammable gas detectors, ultrasonic detectors and flame detectors). In case of ESD system activation, the cold box is shut down and isolated, the LNG is drained in two minutes towards the LNG drain K.O. Drum and vaporized to the cold vent. In this way all the LNG (liquid phase) is rapidly removed from the cold box, minimizing the possibility of escalation to the adjacent equipment. After the liquid drainage, the gas depressurization is also conducted and the cold box is flushed with nitrogen.

- The LNG storage tanks, that are the equipment containing the largest quantity of flammable substance, have been located at 19 m away from the cold box.
- The NG and BOG compressors are located within the identified level contour (19 m). However, a F&G system, which automatically initiates emergency actions (ESD), is foreseen in the liquefaction area (presence of flammable gas detectors, ultrasonic detectors and flame detectors). In case of ESD procedure activation, both the compressors' systems are shut down and isolated, the natural gas is depressurized in one minute towards the cold vent, minimizing the flammable substance quantity in the relevant isolatable sections. After the depressurization, the machines are flushed with nitrogen.
- The NG precooling and drying unit (DU4000), the NG regeneration module (MDL5000) and the HC heater module (MDL9000) are located within the identified level contour (19 m). However, a F&G system, which automatically initiates emergency actions (ESD), is foreseen in the liquefaction area (presence of flammable gas detectors, ultrasonic detectors and flame detectors). In case of ESD procedure activation, the sections are shut down and isolated. Then, the nitrogen flushing procedure towards the cold vent is initiated, since the section is at low operating pressure.
- A firefighting network is foreseen in the area.

Furthermore, the followings design features should be also considered:

- All the cryogenic equipment (heat exchanger, valves, piping) of the LNG liquefier cold box (item CB7000) are installed inside a vertical enclosure made in carbon steel; the enclosure is manufactured with structural beams and covered with 3 mm thickness plates. The hollow space between the enclosure and the internal equipment is filled with perlite, an incombustible material used to thermally insulate the cold parts. The cold box enclosure is purged with nitrogen to avoid external ambient air humidity entrance and to keep an inert atmosphere inside. On the casing roof a 600 mm diameter manhole is installed; the manhole acts also as an overpressure protection for the casing (bursting pressure: 0.0175 bar). All connections inside the enclosure, both for natural gas and LNG side, are butt-welded. Only the natural gas inlet and LNG outlet tie-ins outside the casing are flanged. All the tie-in connections are placed in the lower part of cold box (at man height), concentrated in the south side of the cold box. The consequences relevant to TE03 may be mitigated, in view of the mentioned configuration, with respect to the ones shown in paragraph B.2.3.2.
- For what concern the heaters EW5000 (included in module MDL5000) and EW9000 (included in module MDL9000), the flammable gas flows al low pressure through pipe coils immersed in hot water bath. This configuration reduces the heat transfer from a potential external fire (i.e. TE03), without direct exposure of the internal pipes to the flame.

According to fire scenario simulation results for **TE03** (shown in paragraph B.2.3.2) in case of a jet fire from the cold box, the maximum calculated downwind distance corresponding to the threshold level of 8 kW/m^2 (reference threshold value for technical buildings) is 21 m. The determined heat radiation contour does not reach the local control room (LCR) and the driver's container as well.

According to flammable gas dispersion simulation results for **TE03** (shown in paragraph B.2.3.3) the maximum calculated downwind distance corresponding to the LEL concentration is equal to 14.3 m. In view of the determined results the followings should be considered:

- The plant is unmanned, with the exceptions of personnel responsible of loading operations.
- The calculated gas cloud concentration does not reach the loading bays, the LCR and driver's container.

According to fire scenario simulation results for **TE05** (shown in paragraph B.2.3.2) in case of a jet fire from the loading pumps, the maximum calculated downwind distance corresponding to the threshold level of 15 kW/m^2 (reference threshold value for process equipment) is 14 m. The determined heat

radiation contour may reach other nearby equipment belonging to other isolatable sections, nevertheless, the followings safety measures are in place to reduce the potential fire scenario effects:

- A F&G system (presence of flammable gas detectors and flame detectors), which automatically initiates emergency actions (ESD), is foreseen in the pump loading area. In case of ESD system activation, the loading pumps are shut down and isolated. In addition, ESD push buttons are installed at loading bays for manual ESD activation by plant operators.
- The truck loading bays are located within the identified level contour (14 m). However, a fire-resistant separation wall is placed between pumps and loading area, in order to avoid the possibility of a jet fire escalation from the pumps to the adjacent trucks.
- A firefighting network is foreseen in the area.

Furthermore, the followings design features should be also considered:

- The LNG tank trucks consist of double wall containment vessels, the hollow space between the two walls is in full vacuum conditions and filled with insulating material (perlite). This configuration reduces the heat transfer without direct exposure of the inner tank to the flame.
- The truck loading pumps are submerged type with high integrity seals. The motor is submerged inside a cryostat with no possibility of LNG leakage from the seals. Therefore, the equipment release frequency would be lower than the centrifugal pump one considered in the frequency assessment (paragraph B.2.2.1).

According to fire scenario simulation results for **TE05** (shown in paragraph B.2.3.2) in case of a jet fire from the loading pumps, the maximum calculated downwind distance corresponding to the threshold level of 8 kW/m^2 (reference threshold value for technical buildings) is 15.1 m. The determined heat radiation contour does not reach the local control room (LCR) and the driver's container as well.

According to flammable gas dispersion simulation results for **TE05** (shown in paragraph B.2.3.3) the maximum calculated downwind distance corresponding to the LEL concentration is equal to 14 m. In view of the determined results the followings should be considered:

- The plant is unmanned, with the exceptions of personnel responsible of loading operations.
- The calculated gas cloud concentration does not reach the LCR and driver's container.
- The calculated gas cloud concentration reaches the loading bays. However, it should be considered that, due to low temperatures, the LNG gas cloud behaves as a heavy gas, slumping and spreading on the ground. Considering that the maximum height reached by the cloud is around 1,5 m, the presence of a 3,5 m height wall, between pump and loading areas, is deemed as a physical obstacle to the gas cloud dispersion towards the loading bays, remaining the cloud confined within the pumps area.

According to fire scenario simulation results for **TE06** (shown in paragraph B.2.3.2) in case of a jet fire from the transferring hoses, the maximum calculated downwind distance corresponding to the threshold level of 15 kW/m^2 (reference threshold value for process equipment) is 13.5 m. The determined heat radiation contour may reach other nearby equipment belonging to other isolatable sections, nevertheless, the followings safety measures are in place to reduce the potential fire scenario effects:

- A F&G system (presence of flammable gas detectors and flame detectors) and ESD push buttons, which automatically initiates emergency actions (ESD), are foreseen in the loading bays area. In case of ESD system activation, the loading pumps are shut down and isolated and the LNG inlet valve located on truck is immediately closed. The LNG quantity contained within the considered isolatable section (i.e. from ESD valve downstream loading pump to truck LNG inlet valve) is limited. Considering the calculated release flowrate (paragraph B.2.3.1), the estimated release scenario duration is about a few minutes (< 5 minutes), minimizing the possibility of escalation to adjacent equipment.

- The loading pumps are located within the identified level contour (13.5 m). However, a fire-resistant separation wall is placed between pumps and loading area, in order to avoid the possibility of a jet fire escalation from the loading hoses to the adjacent pumps.
- A firefighting network is foreseen in the area.

Furthermore, the followings design features should be also considered:

- The LNG tank trucks consist of double wall containment vessels, the hollow space between the two walls is in full vacuum conditions and filled with insulating material (perlite). This configuration reduces the heat transfer without direct exposure of the inner tank to the flame.
- The loading hoses are equipped with a breakaway system, with a fast-closing-sealing-valve that immediately stops the fluid flow in case of emergency.
- The operator shall perform the leak test with soapy water on the hose-truck coupling, before initiating the loading procedure, in order to assure a proper connection of the loading hose to the truck.

According to fire scenario simulation results for **TE06** (shown in paragraph B.2.3.2) in case of a jet fire from the transferring hoses, the maximum calculated downwind distance corresponding to the threshold level of 8 kW/m^2 (reference threshold value for technical buildings) is 16 m. The determined heat radiation contour does not reach the local control room (LCR) and the driver's container as well.

According to flammable gas dispersion simulation results for **TE06** (shown in paragraph B.2.3.3) the maximum calculated downwind distance corresponding to the LEL concentration is equal to 14 m. In view of the determined results the followings should be considered:

- The plant is unmanned, with the exceptions of personnel responsible of loading operations.
- The calculated gas cloud concentration does not reach the LCR and driver's container.
- The calculated gas cloud concentration does reach the loading pumps. However, it should be considered that, due to low temperatures, the LNG gas cloud behaves as a heavy gas, slumping and spreading on the ground. Considering that the maximum height reached by the cloud is around 1.5 m, the presence of a 3.5 m height wall, between pump and loading areas, is deemed as a physical obstacle to the gas cloud dispersion towards the loading pumps, remaining the cloud confined within the loading bays.

According to fire scenario simulation results for **TE07** and **TE08** (shown in paragraph B.2.3.2) in case of a jet fire from the NG compressor or BOG compressor, the maximum calculated downwind distance corresponding to the threshold level of 15 kW/m^2 (reference threshold value for process equipment, obtained at 5.8 m and 4.8 m distances respectively) does not reach any other nearby equipment belonging to other isolatable sections. Furthermore, the calculated downwind distance corresponding to the threshold level of 8 kW/m^2 (reference threshold value for technical buildings, obtained at 6.2 m and 5.0 m distances respectively) does not reach the local control room (LCR) and the driver's container as well.

According to flammable gas dispersion simulation results for **TE07** and **TE08** (shown in paragraph B.2.3.3) the maximum calculated downwind distance corresponding to the LEL concentration (i.e. 1 m) does not reach any area with potential presence of personnel (i.e. loading bays, LCR and driver's container).

According to explosion (VCE) simulation results (shown in paragraph B.2.3.3), the main findings are listed hereinafter:

- the overpressure level of 0.3 barg (reference threshold value for process equipment damage) is not reached for any investigated Top Event.

- the overpressure level of 0.14 barg (reference threshold value for buildings and plant personnel) does not reach any technical building (i.e. LCR and driver's container) for all the analyzed Top Event.
- the overpressure level of 0.07 barg (reference threshold value considered for external population) does not reach plant boundaries for any investigated Top Event.

In view of the plant location and according to the consequences modelling results (paragraph B.2.3), the following considerations apply to the plant boundaries:

- The heat radiation level contour of 13 kW/m^2 (i.e. the maximum threshold level for isolated areas) does not reach the plant boundary West side (vegetation area).
- The heat radiation level contour of 5 kW/m^2 (i.e. the maximum threshold level for intermediate areas), does not reach the plant boundary East side (industrial area).
- The heat radiation level contour of 1.5 kW/m^2 (i.e. the maximum threshold level for critical areas) is considered as not applicable to the Project, since no critical areas (e.g. hospital, sports stadium, play ground, etc.) are located around the Plant.
- Flammable gas dispersion contour corresponding to LEL concentration does not reach any plant boundary.

ANNEX C - CONSEQUENCE ANALYSIS MAPPING

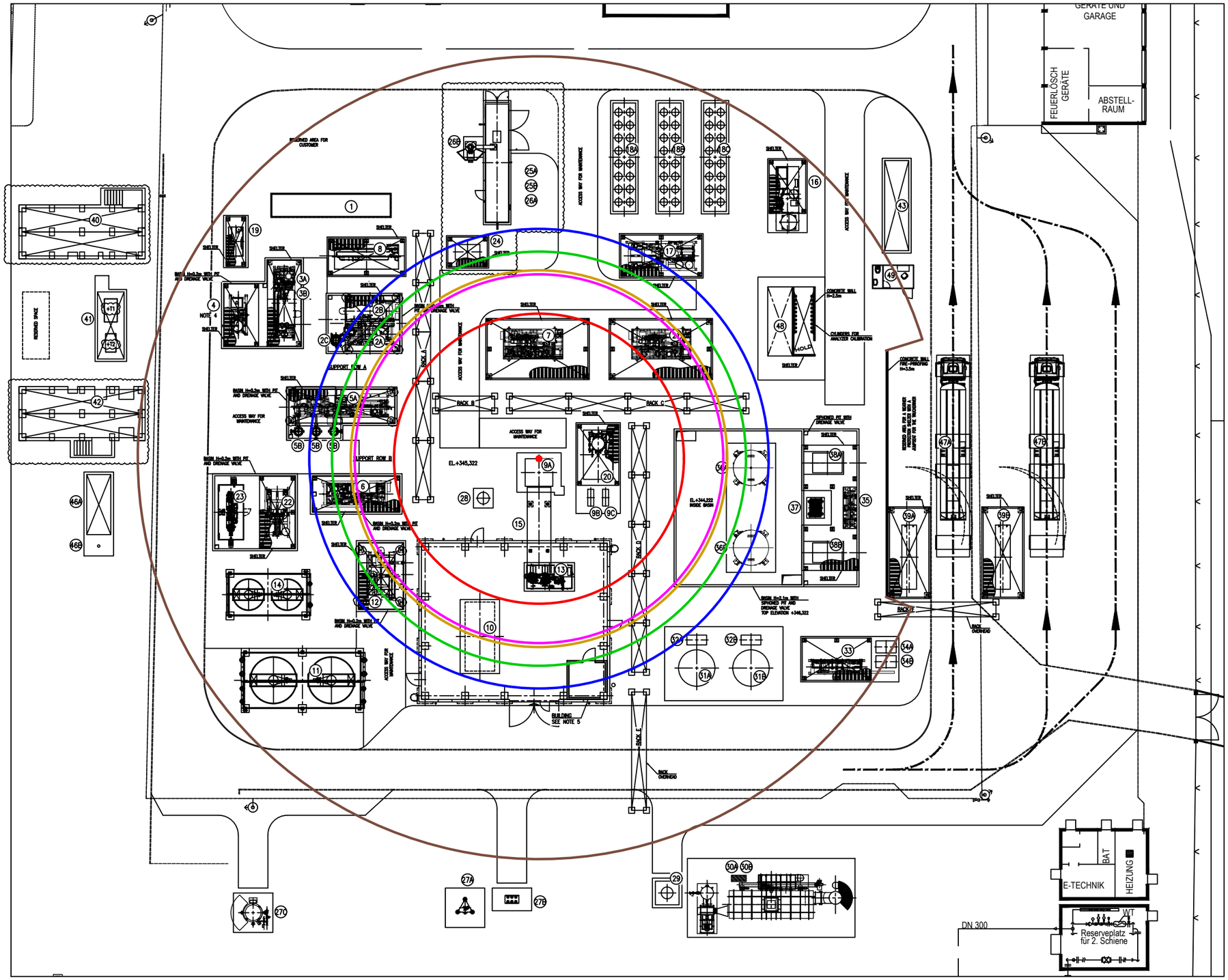
LIST OF FIGURES:

FIGURE 1

– TOP EVENT 3 –

PASQUILL STABILITY CLASS 2F

- Flame leght (14.7m)
- 15 kW/m² (18.7m)
- 13 kW/m² (19.1m)
- 8 kW/m² (21.0m)
- 5 kW/m² (23.3m)
- 1.5 kW/m² (40.7m)



PLAN VIEW

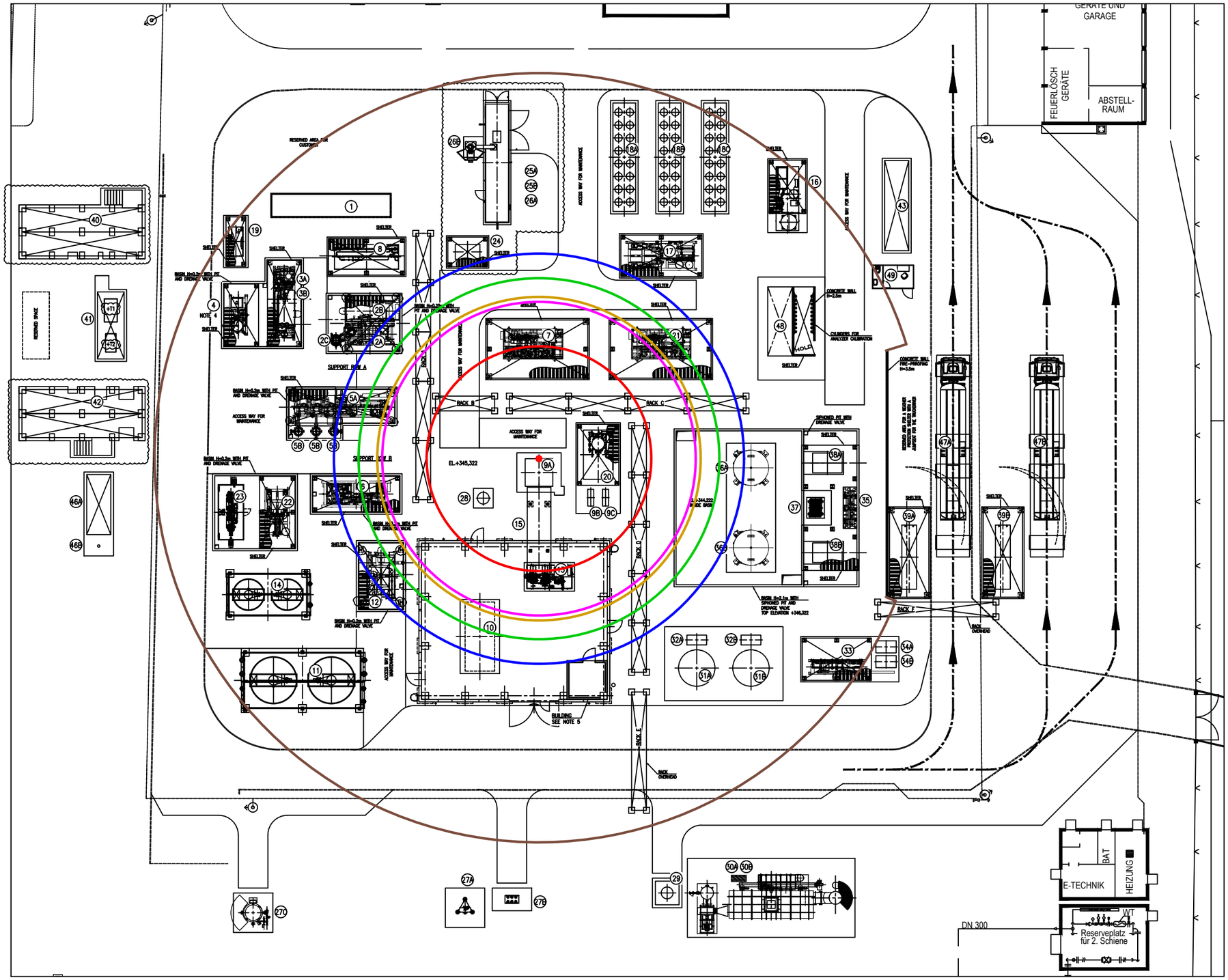
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 2

JET FIRE – TOP EVENT 3 –

PASQUILL STABILITY CLASS 5D

- Flame leght (11.4m)
- 15 kW/m² (15.9m)
- 13 kW/m² (16.4m)
- 8 kW/m² (18.3m)
- 5 kW/m² (20.8m)
- 1.5 kW/m² (39.0m)



PLAN VIEW

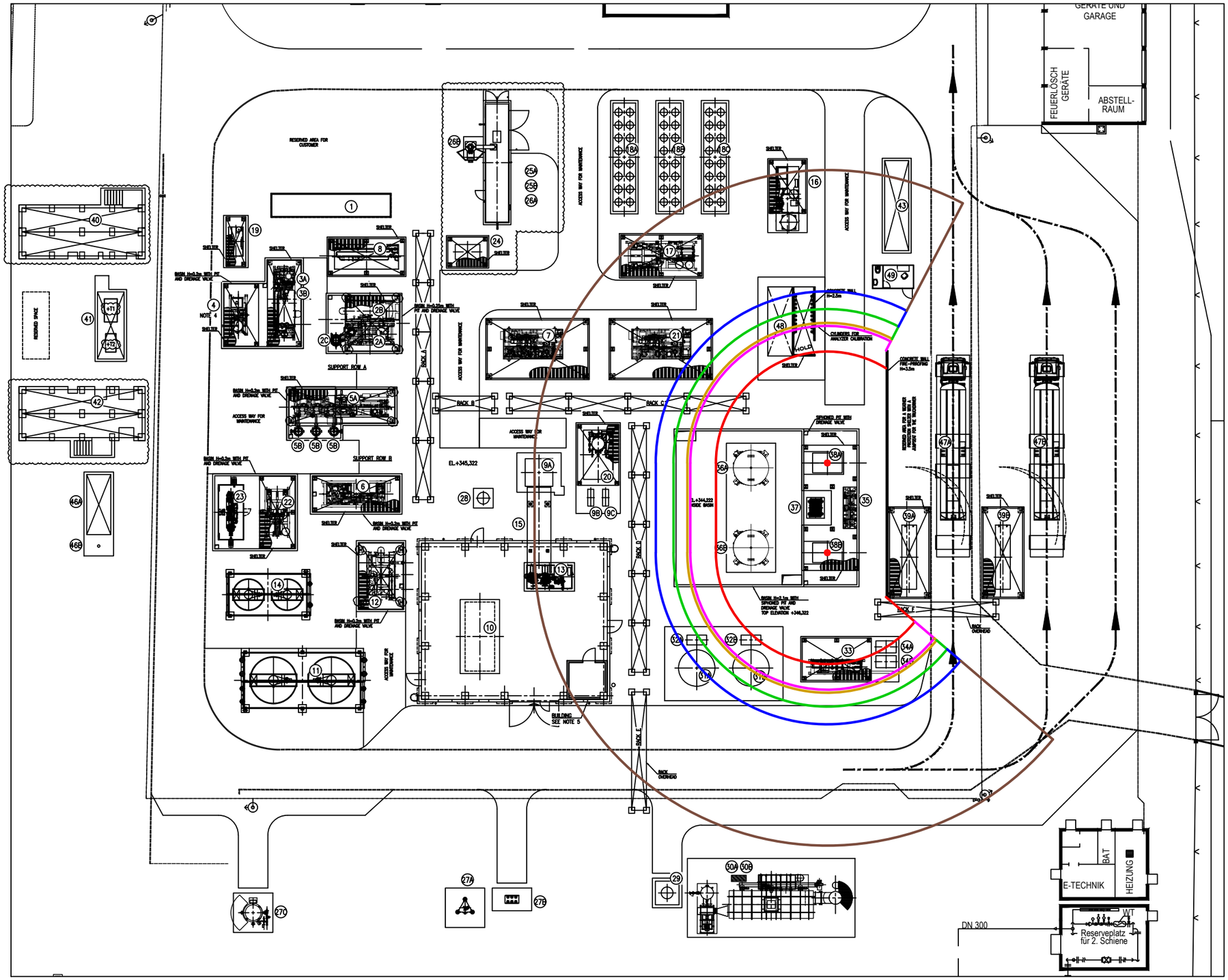
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EW5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 3

JET FIRE – TOP EVENT 5 –

PASQUILL STABILITY CLASS 2F

- Flame leght (11.3m)
- 15 kW/m² (13.9m)
- 13 kW/m² (14.2m)
- 8 kW/m² (15.6m)
- 5 kW/m² (17.4m)
- 1.5 kW/m² (29.7m)



PLAN VIEW

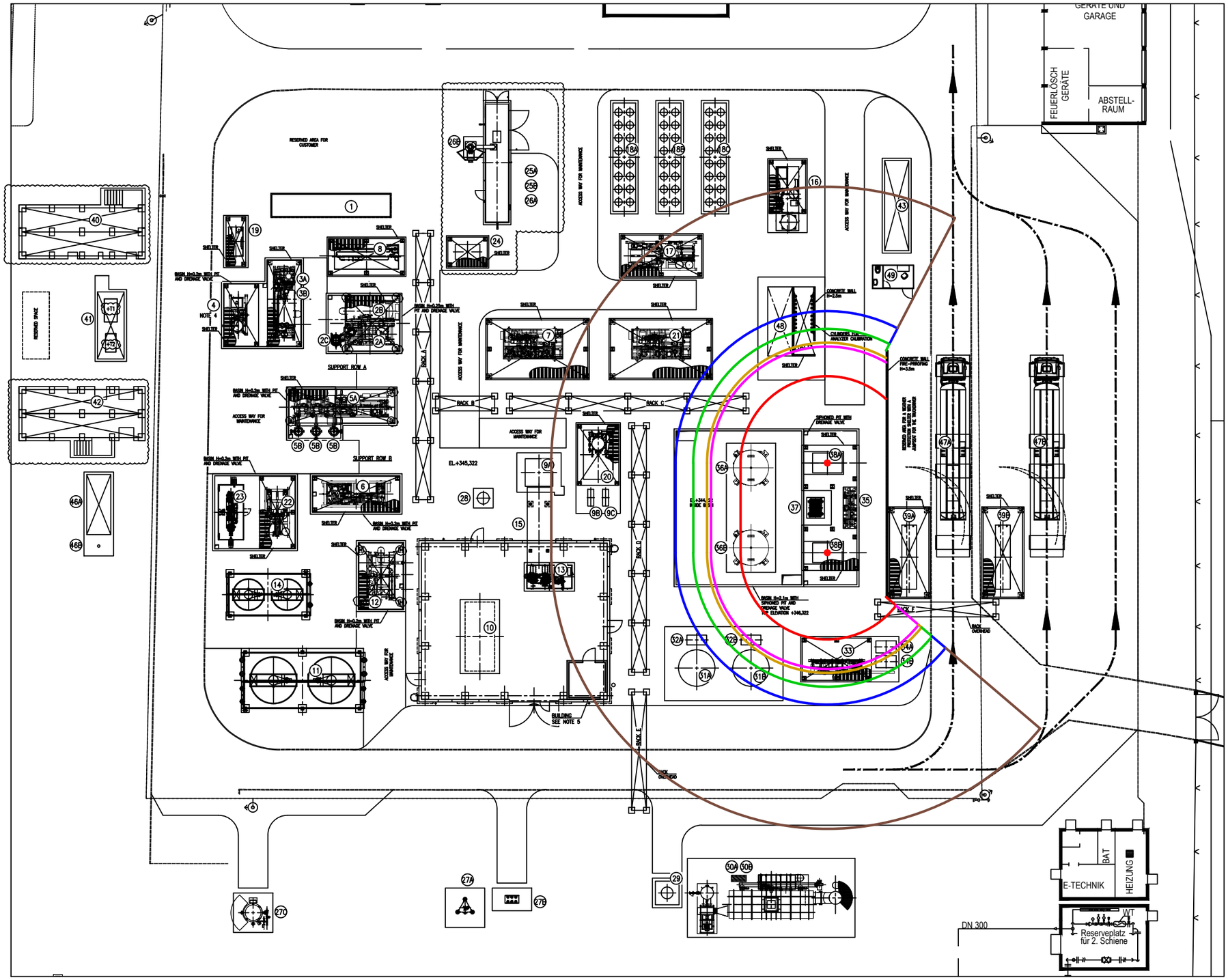
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 4

JET FIRE – TOP EVENT 5 –

PASQUILL STABILITY CLASS 5D

- Flame leght (8.8m)
- 15 kW/m² (11.8m)
- 13 kW/m² (12.2m)
- 8 kW/m² (13.6m)
- 5 kW/m² (15.4m)
- 1.5 kW/m² (28.0m)



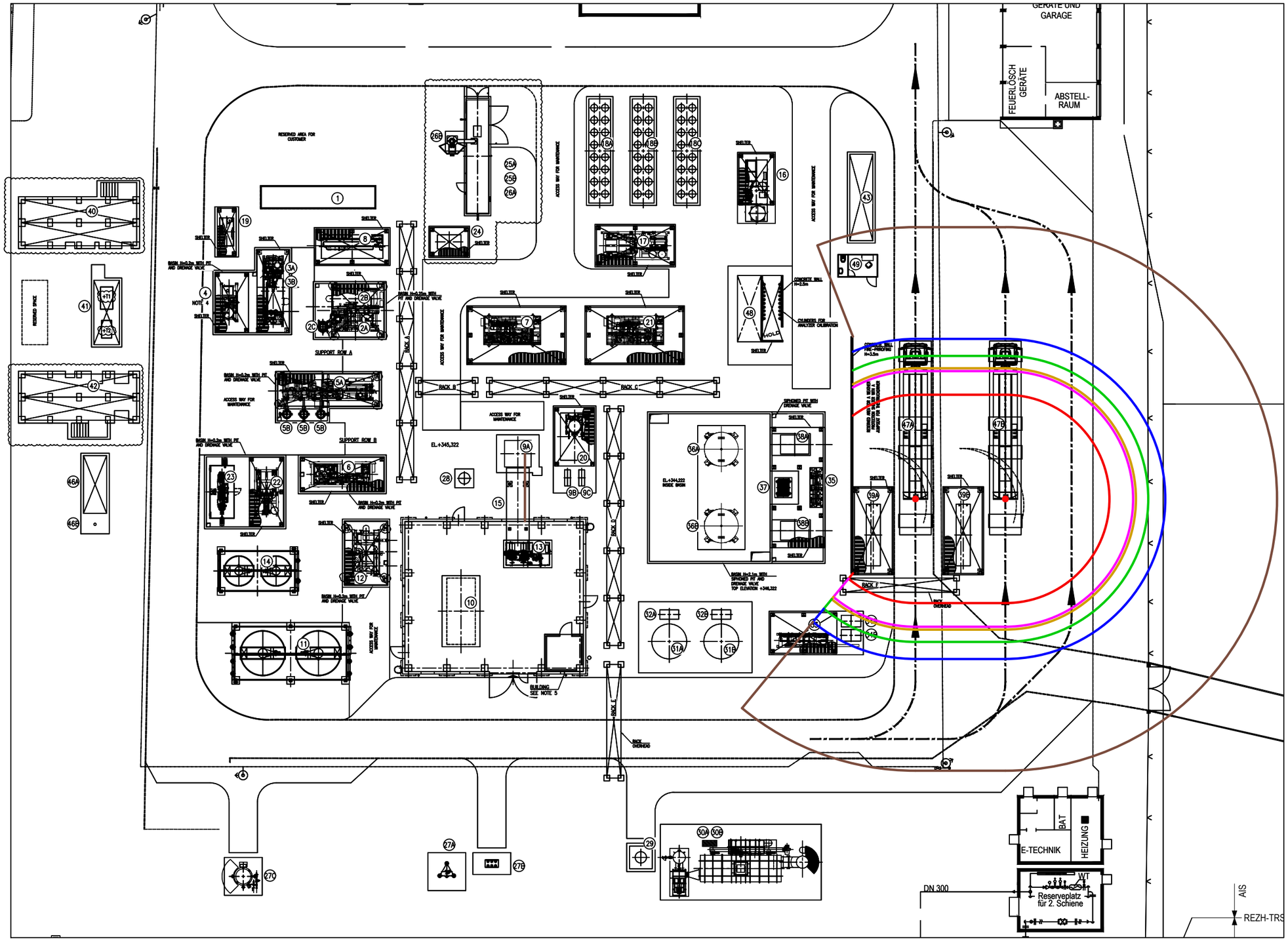
PLAN VIEW

ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 5

JET FIRE – TOP EVENT 6 –
PASQUILL STABILITY CLASS 2F

- Flame leght (11.0m)
- 15 kW/m² (13.5m)
- 13 kW/m² (13.8m)
- 8 kW/m² (15.1m)
- 5 kW/m² (16.9m)
- 1.5 kW/m² (28.7m)



PLAN VIEW

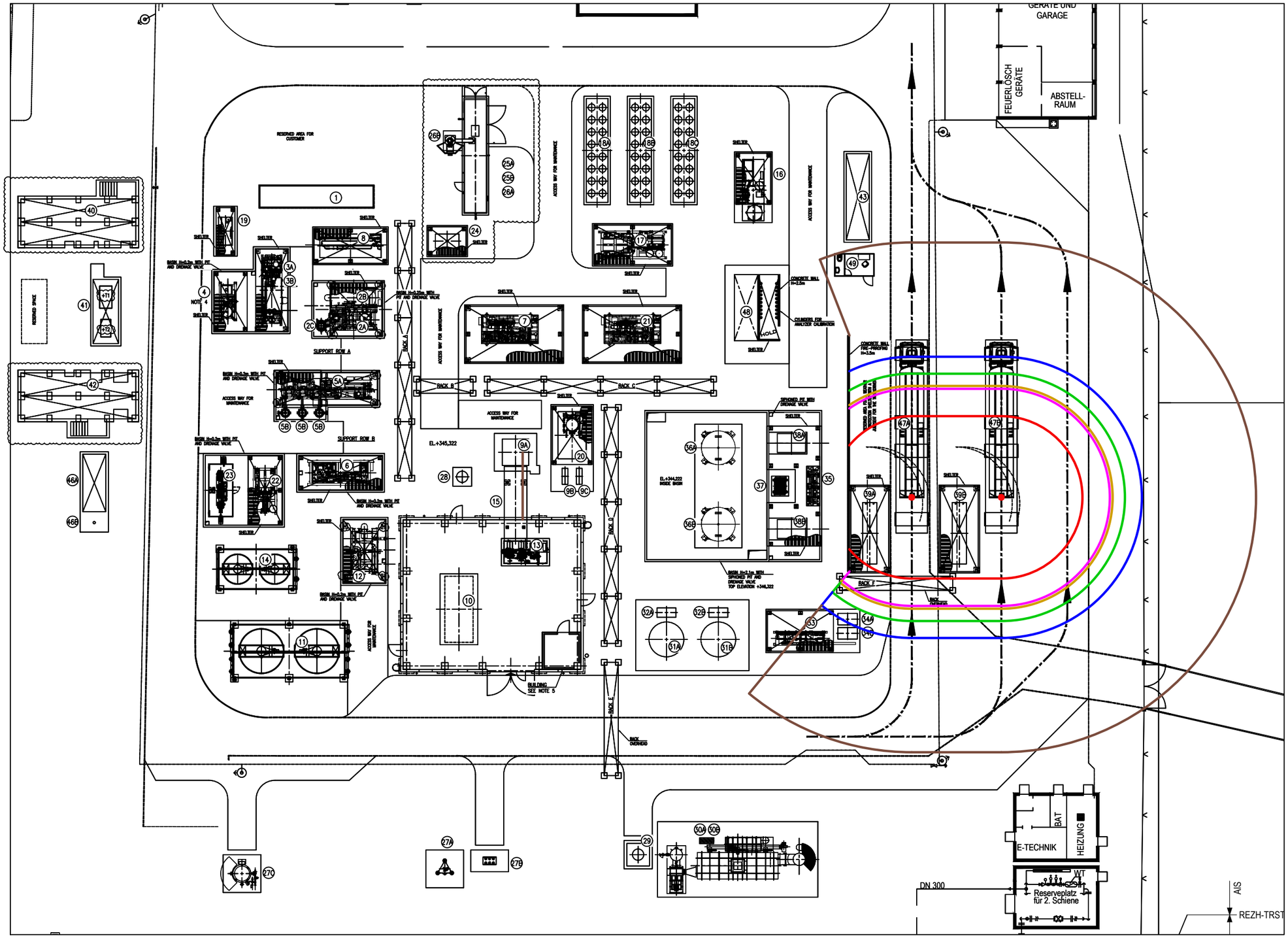
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EW5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 6

JET FIRE – TOP EVENT 6 –

PASQUILL STABILITY CLASS 5D

- Flame leght (8.6m)
- 15 kW/m² (11.5m)
- 13 kW/m² (11.8m)
- 8 kW/m² (13.1m)
- 5 kW/m² (14.9m)
- 1.5 kW/m² (27.0m)



PLAN VIEW

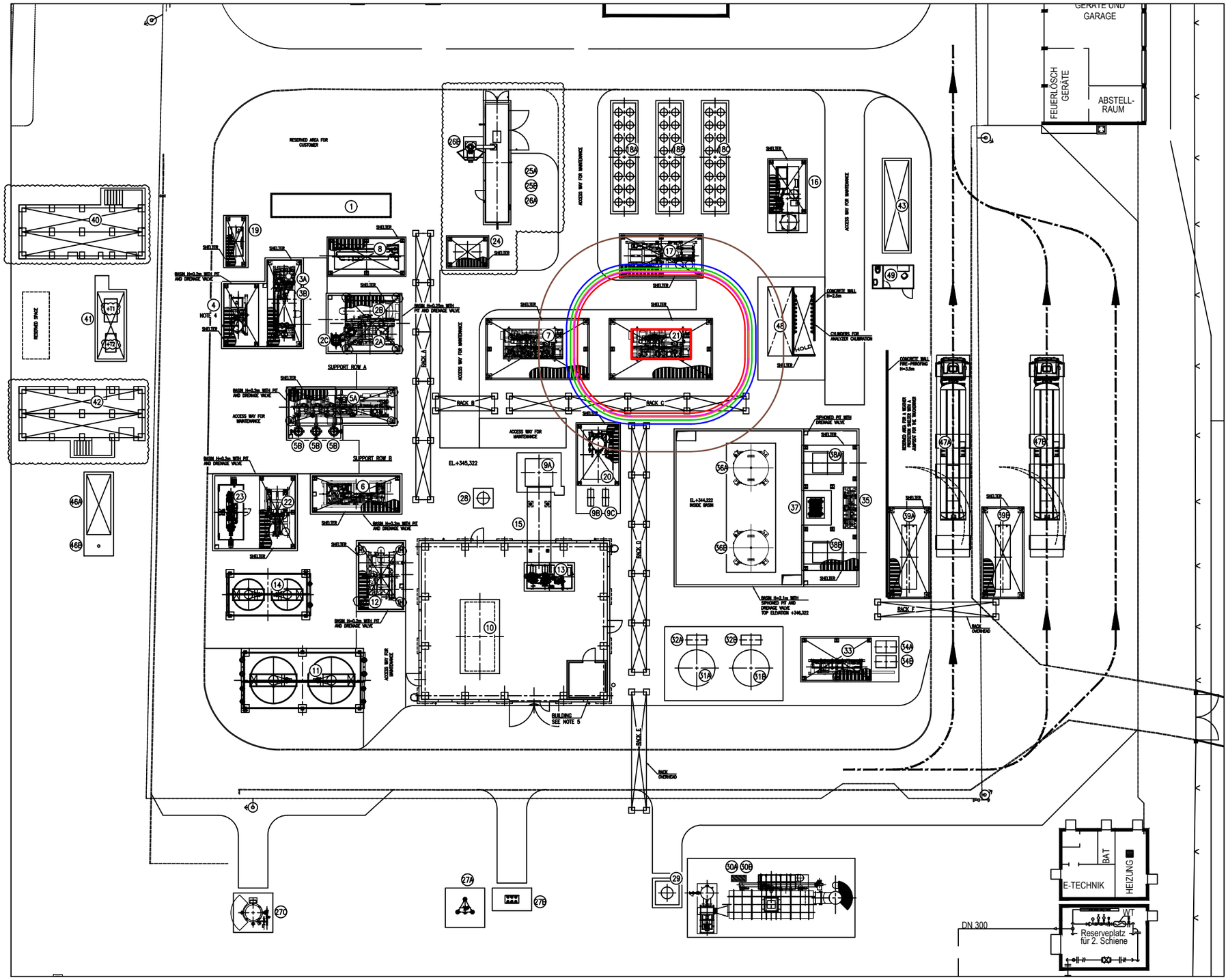
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EW5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 7

JET FIRE – TOP EVENT 7 –

PASQUILL STABILITY CLASS 2F

- Flame leght (5.5m)
- 15 kW/m² (5.8m)
- 13 kW/m² (5.9m)
- 8 kW/m² (6.2m)
- 5 kW/m² (6.6m)
- 1.5 kW/m² (9.4m)



PLAN VIEW

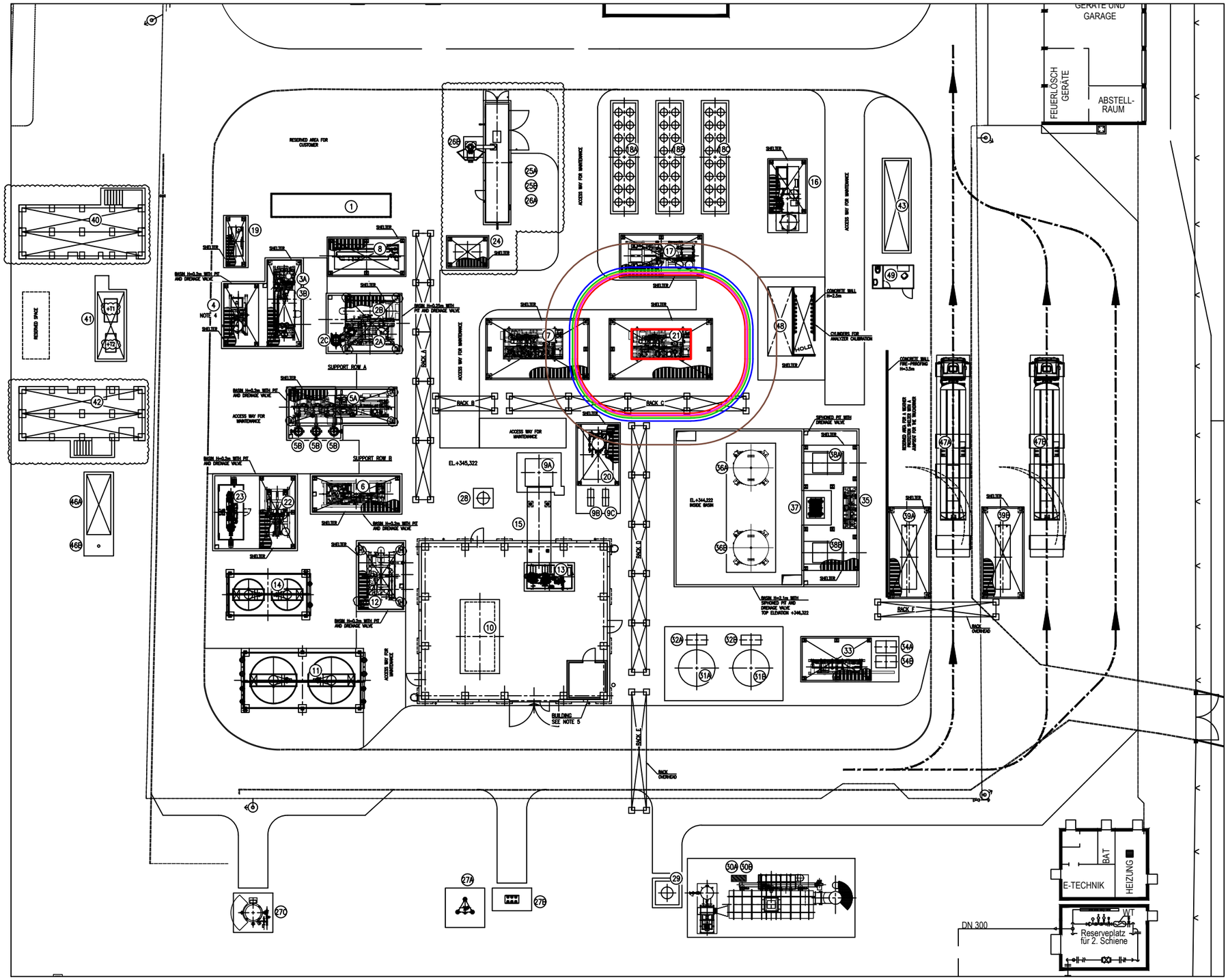
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EH5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 8

JET FIRE – TOP EVENT 7 –

PASQUILL STABILITY CLASS 5D

- Flame leght (5.5m)
- 15 kW/m² (5.7m)
- 13 kW/m² (5.8m)
- 8 kW/m² (6.0m)
- 5 kW/m² (6.3m)
- 1.5 kW/m² (8.7m)



PLAN VIEW

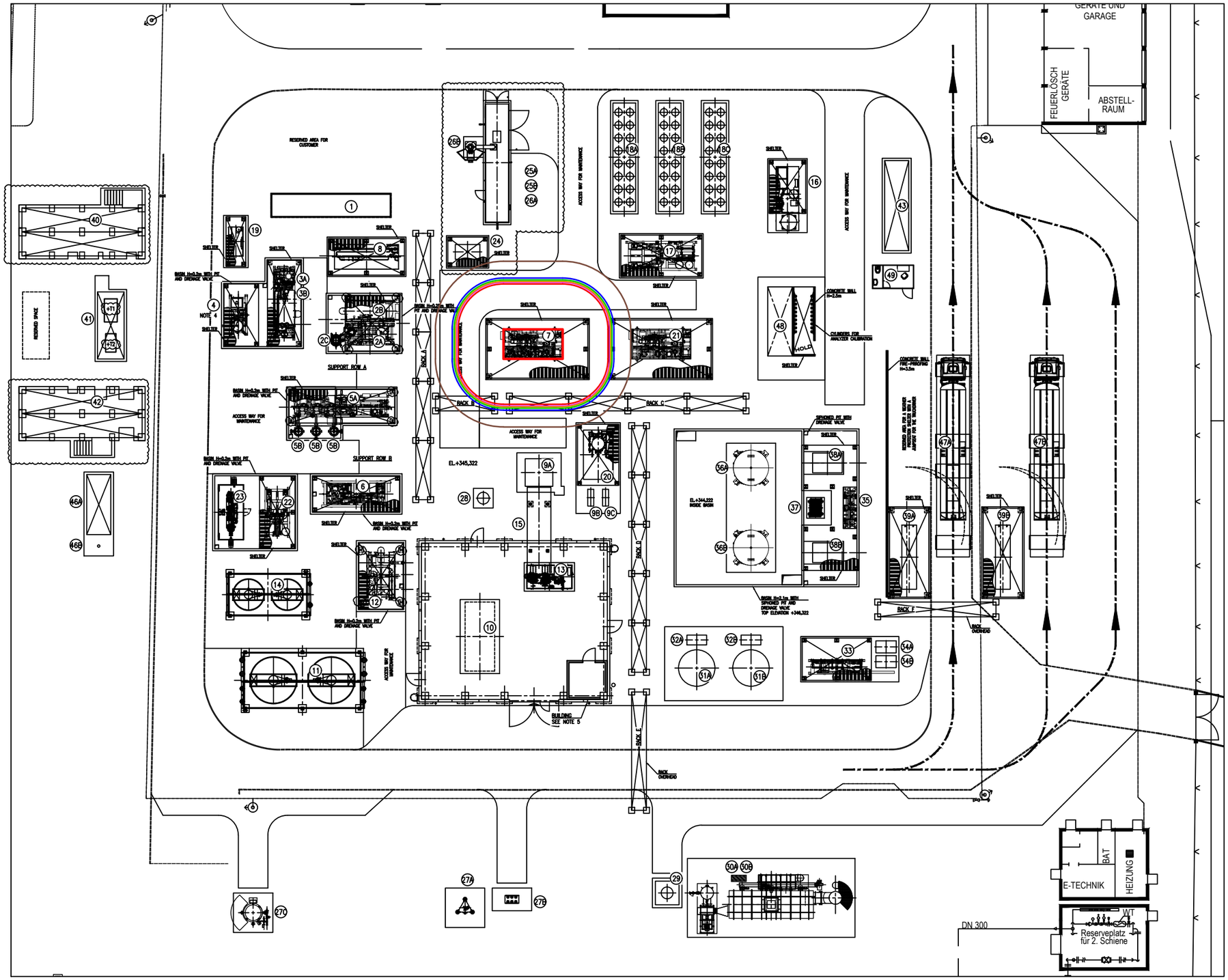
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EW5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 9

JET FIRE – TOP EVENT 8 –

PASQUILL STABILITY CLASS 2F

- Flame leght (4.6m)
- 15 kW/m² (4.8m)
- 13 kW/m² (4.8m)
- 8 kW/m² (5.0m)
- 5 kW/m² (5.2m)
- 1.5 kW/m² (6.9m)



PLAN VIEW

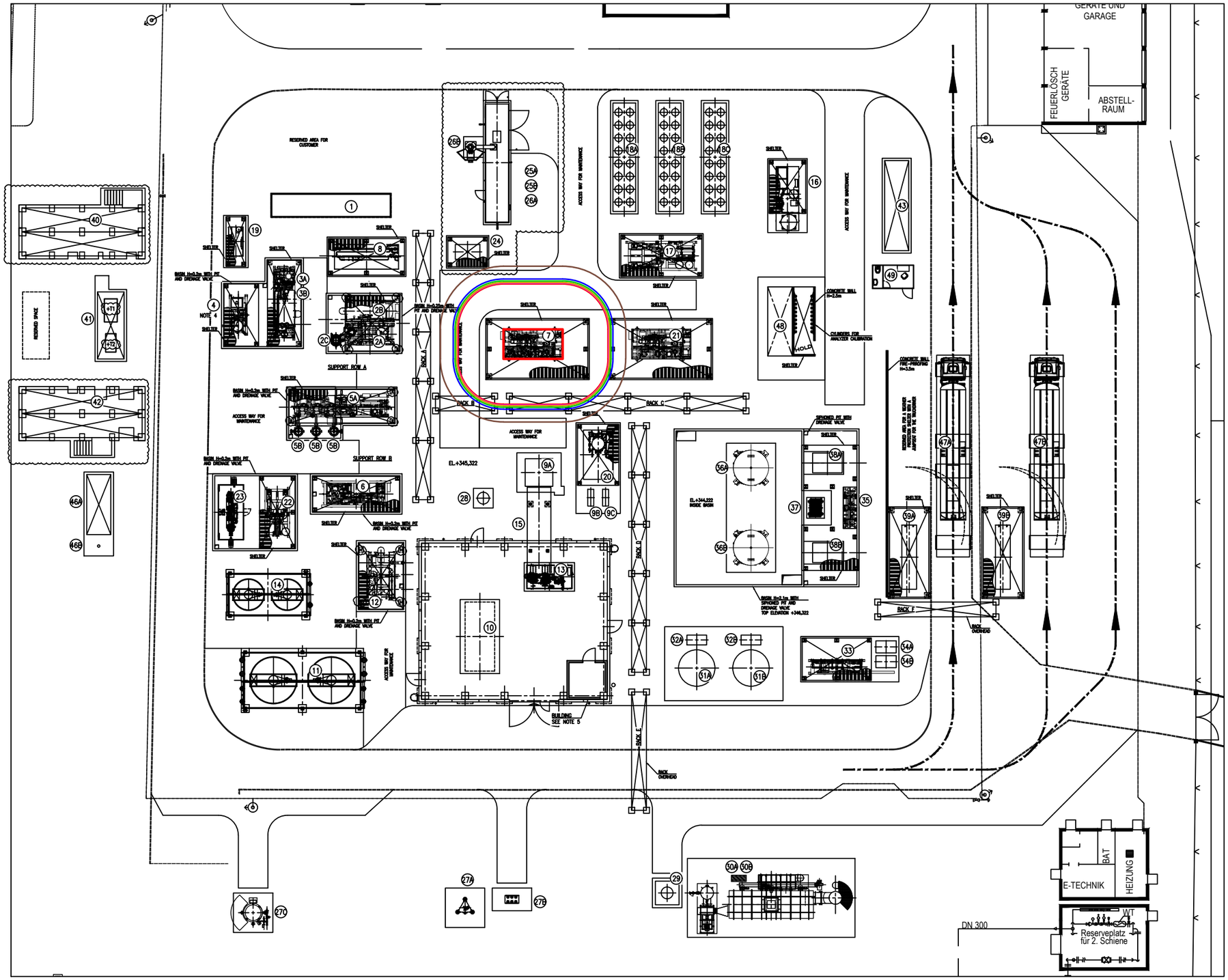
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EW5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 10

JET FIRE – TOP EVENT 8 –

PASQUILL STABILITY CLASS 5D

- Flame leght (4.6m)
- 15 kW/m² (4.7m)
- 13 kW/m² (4.7m)
- 8 kW/m² (4.9m)
- 5 kW/m² (5.1m)
- 1.5 kW/m² (6.4m)



PLAN VIEW

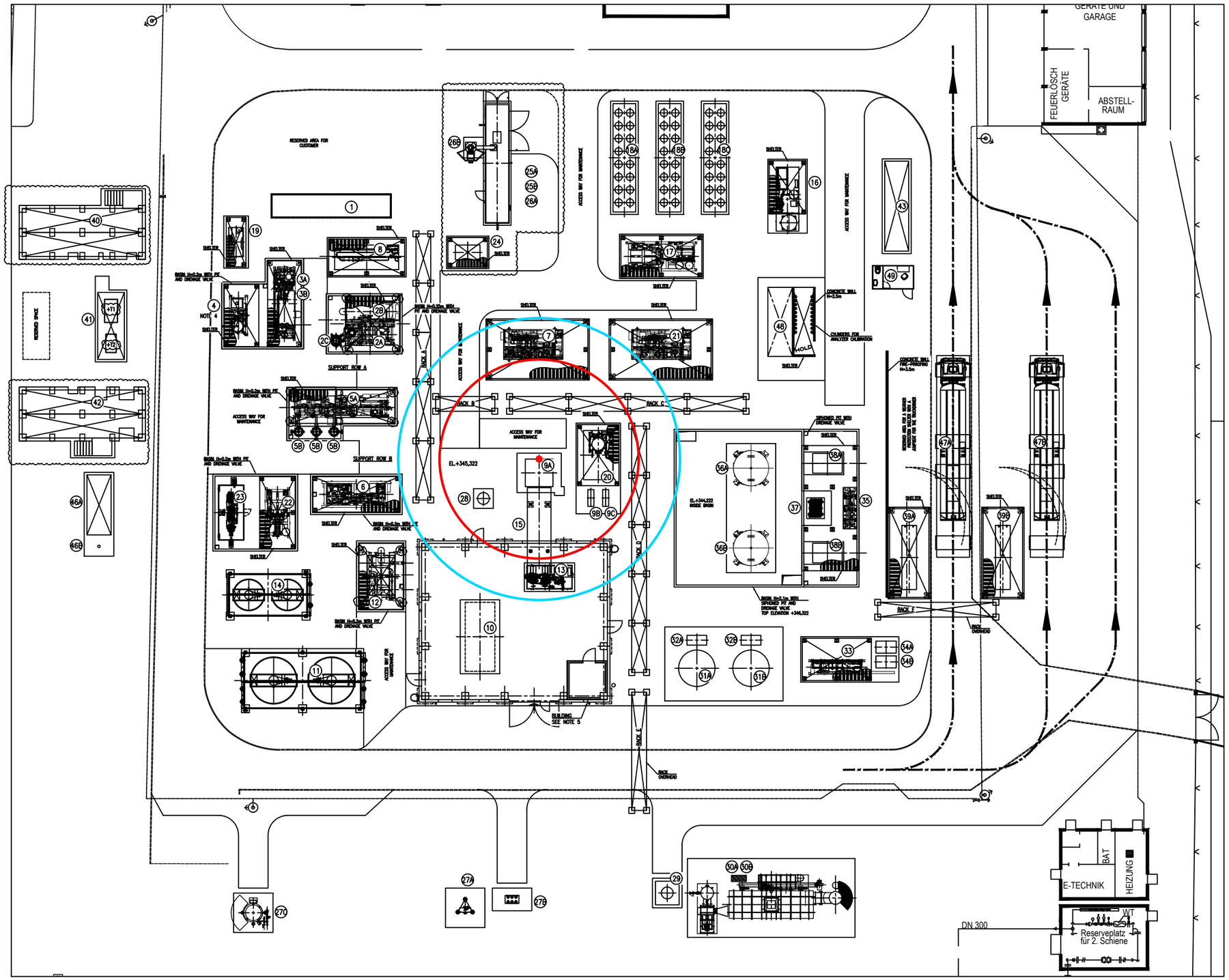
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EH5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 11

FLASH FIRE – TOP EVENT 3 –
PASQUILL STABILITY CLASS 2F AND 5D

LEL PASQUILL STABILITY CLASS 2F (14.3m)

LEL PASQUILL STABILITY CLASS 5D (10.1m)



PLAN VIEW

ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HW5000 ST5000 EH05000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HW6000 RS60000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HW7400 HW7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EW9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HW15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

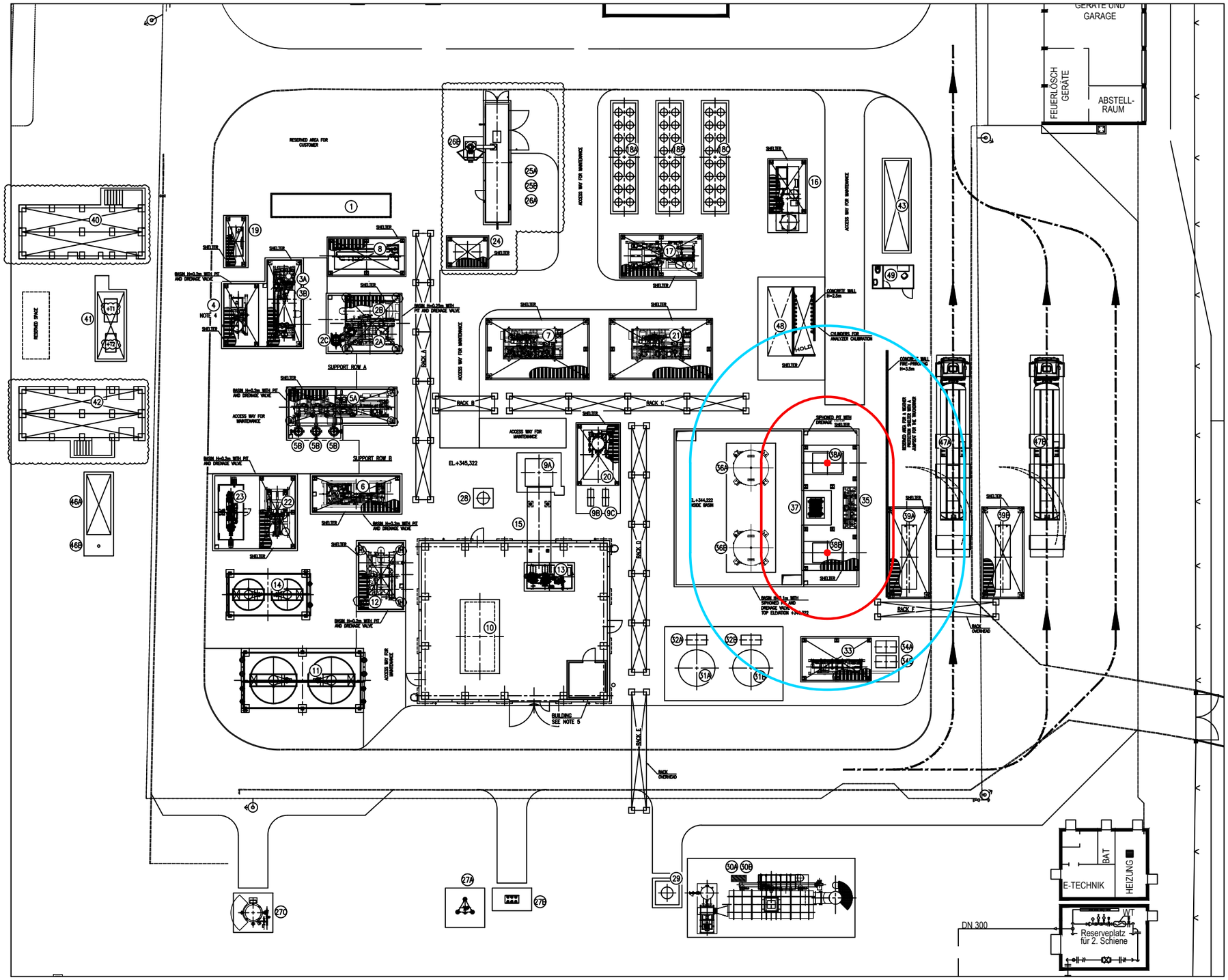
FIGURE 12

FLASH FIRE – TOP EVENT 5 –

PASQUILL STABILITY CLASS 2F AND 5D

LEL PASQUILL STABILITY CLASS 2F (13.9m)

LEL PASQUILL STABILITY CLASS 5D (6.7m)



PLAN VIEW

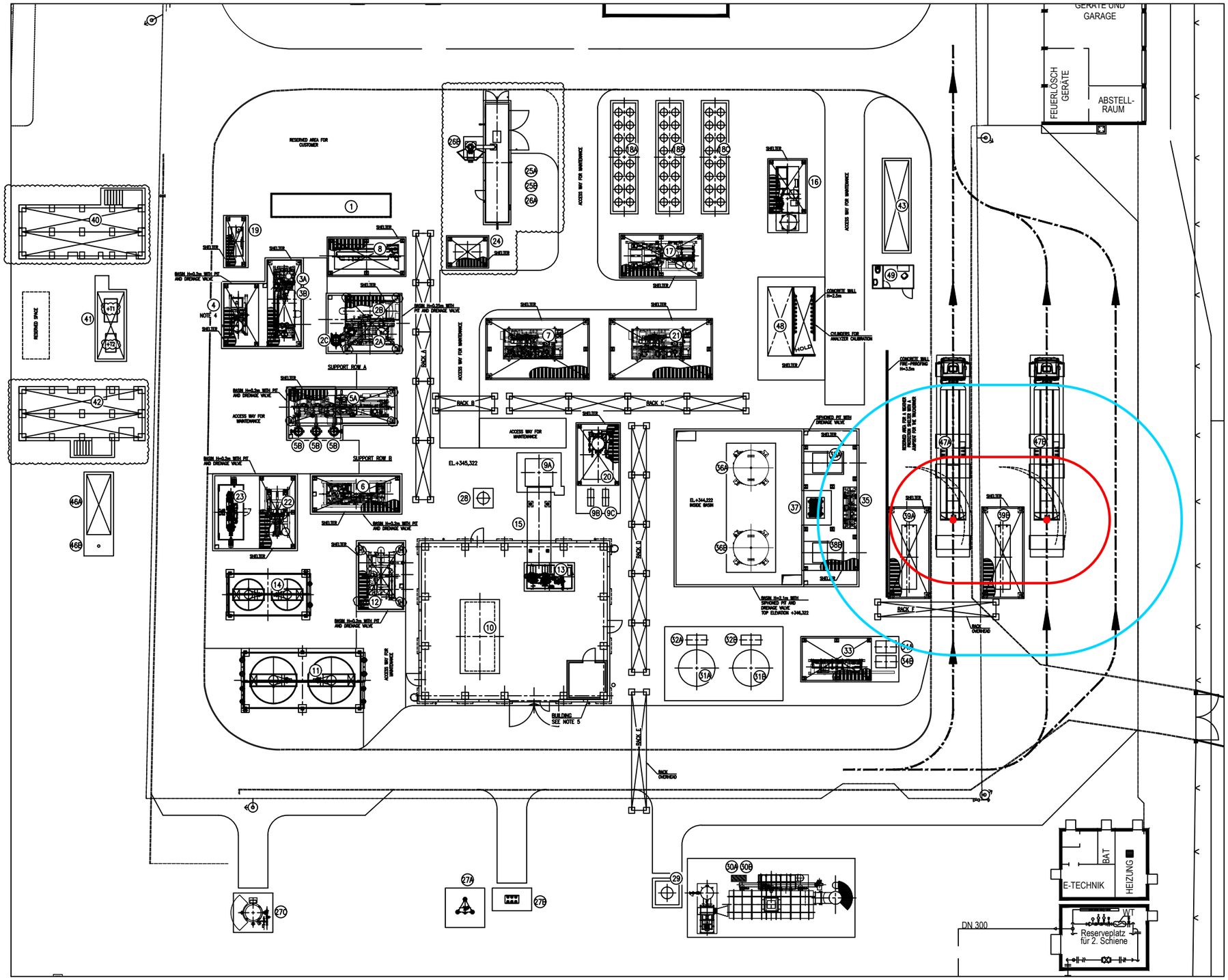
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 13

FLASH FIRE – TOP EVENT 6 –
PASQUILL STABILITY CLASS 2F AND 5D

LEL PASQUILL STABILITY CLASS 2F (13.7m)

LEL PASQUILL STABILITY CLASS 5D (6.4m)



PLAN VIEW

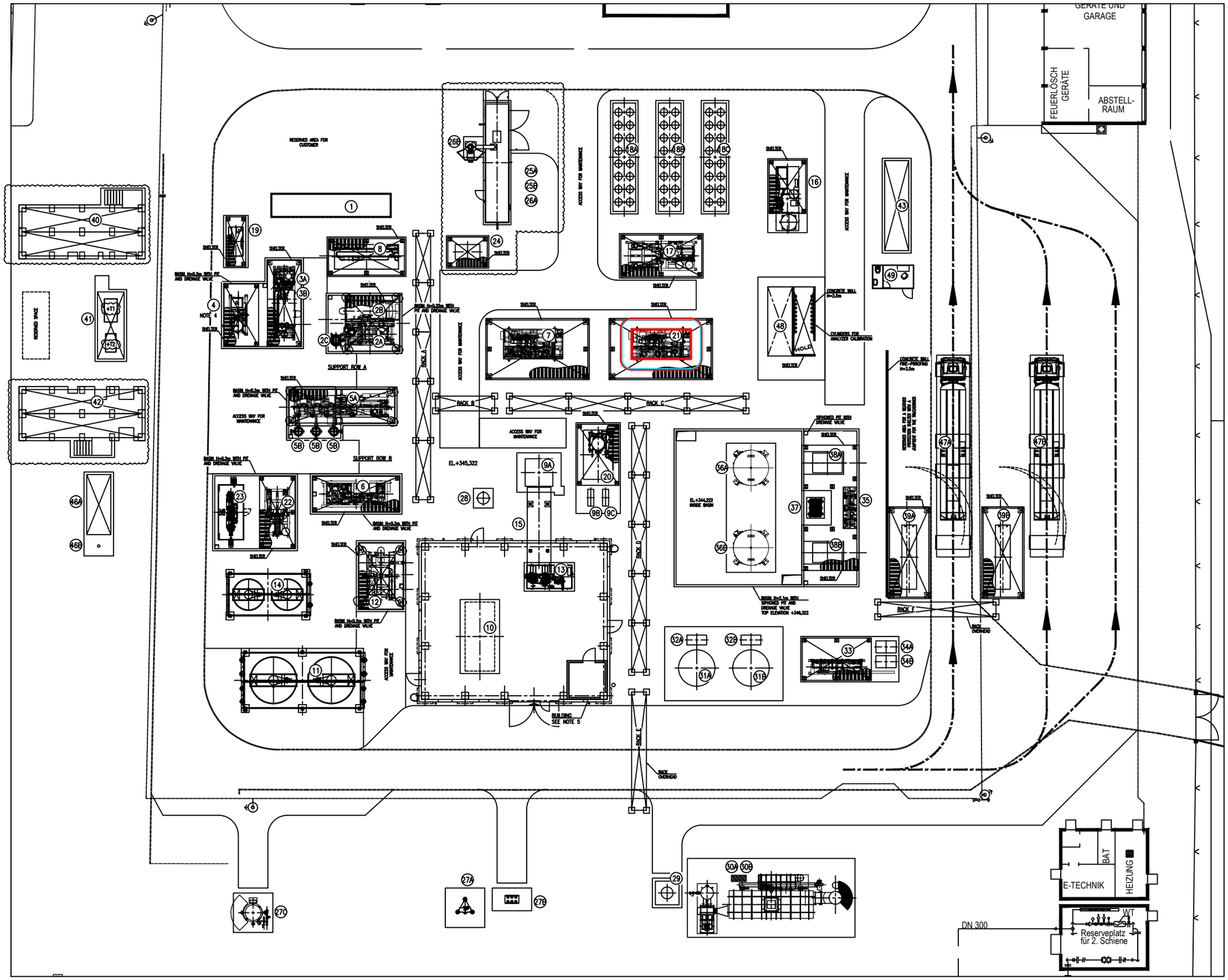
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 14

FLASH FIRE – TOP EVENT 7 – PASQUILL STABILITY CLASS 2F AND 5D

LEL PASQUILL STABILITY CLASS 2F (1.0m)

LEL PASQUILL STABILITY CLASS 5D (1.0m)



PLAN VIEW

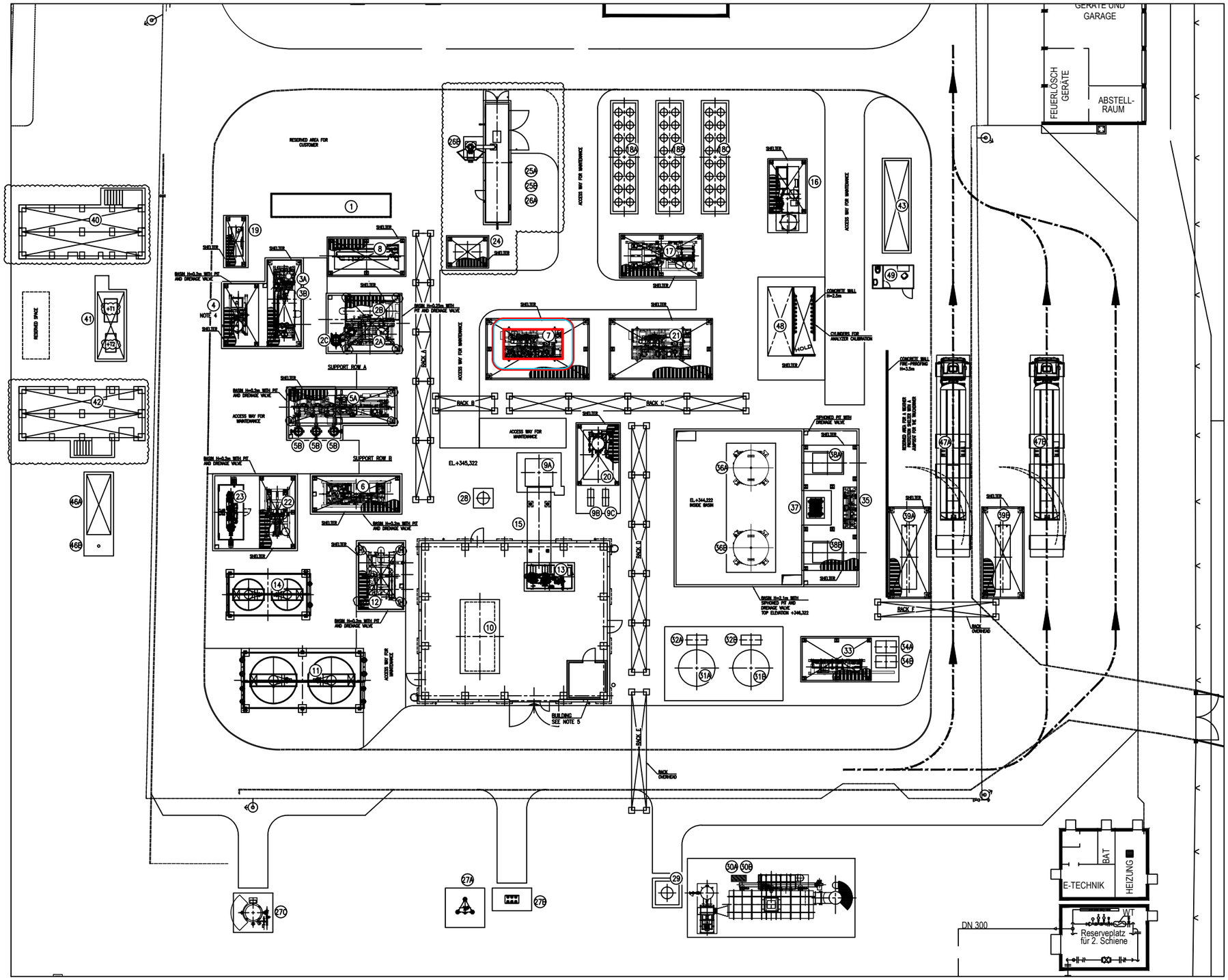
ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–

FIGURE 15

FLASH FIRE – TOP EVENT 8 – PASQUILL STABILITY CLASS 2F AND 5D

LEL PASQUILL STABILITY CLASS 2F (1.0m)

LEL PASQUILL STABILITY CLASS 5D (1.0m)



PLAN VIEW

ITEMS LIST			
	POS.	DESCRIPTION	ITEM
NG PRE-TREATMENT	1	FISCAL METERING STATION (EXCLUDED FROM SCOPE OF SUPPLY)	–
	2A	CO_2 ABSORPTION UNIT – SKID	AU1000
	2B	CO_2 ABSORPTION UNIT – SKID FLASH	
	2C	CO_2 ABSORPTION UNIT – TOWER	
	3A	STRIPPING UNIT – SKID	SU2000
	3B	STRIPPING UNIT – TOWER	
	4	SOLVENT ADDITION AND REMOVAL UNIT	SRU3000
	5A	NG PRECOOLING AND DRYING UNIT – SKID	DU4000
	5B	NG PRECOOLING AND DRYING UNIT – DRYER	
	6	NG REGENERATION MODULE NG REGENERATION COOLER NG CONDENSATE SEPARATOR NG REGENERATION HEATER	MDL5000 HM5000 ST5000 EM5000
	7	NG REGENERATION COMPRESSOR	C5500
	8	FEED GAS MODULE NG PRE-HEATER NG REDUCTION STATION	MDL6000 HM6000 RS6000
LIQUEFACTION UNIT	9A	COLD-BOX PRIMARY HEAT EXCHANGER LNG SUBCOOLER HEAT EXCHANGER LNG SUBCOOLER LNG SEPARATOR	CB7000 HX7000 HX7001 SC7001 S7003
	9B	LIN DRAIN VAPORIZER	E7001
	9C	LNG DRAIN VAPORIZER	E7002
	10	N_2 RECYCLE COMPRESSOR	C7400
	11	N2 RECYCLE COMPRESSOR INTERCOOLER / AFTERCOOLER	E7400/7401
	12	RECYCLE/BOOSTER MODULE N_2 RECYCLE COMPRESSOR POST-AFTERCOOLER COLD BOOSTER POST-AFTERCOOLER	MDL7500 HM7400 HM7601
	13	WARM AND COLD BOOSTER/TURBINE	T/C7500/7600
	14	WARM AND COLD BOOSTER AFTERCOOLER	E7500/7600
	15	TURBINE DUCT	TD7500
UTILITIES	16	INSTRUMENT AIR PACKAGE	IA7700
	17	COOLING WATER MODULE COOLING WATER PUMPS COOLING WATER EXPANSION DRUMS	MDL8000 P8000A/B V8000/8001
	18A/B/C	COOLING WATER AIR COOLER	E8000/8001/8002
	19	DEMI WATER PACKAGE	DW8000
	20	HC HEATER MODULE HC HEATER	MDL9000 EM9000
	21	BOG COMPRESSOR	C9100
	22	CHILLED WATER MODULE CHILLED WATER EXPANSION DRUM CHILLED WATER PUMPS	MDL11000 V11000 P11000A/B
	23	CHILLER	FRU11000
	24	STEAM CONDENSATE MODULE ATMOSPHERIC STEAM CONDENSER CONDENSATE TRANSFER PUMP	MDL15000 HM15000 P15000
	25A	WATER SERVICE MODULE	V15100
	25B	PUMPS MODULE	P15100A/B
	26A	STEAM BOILER	SG15200
	26B	STEAM BOILER – CHIMNEY	–
VENT SYSTEM	27A	VENT	FL16000
	27B	SNUFFING SYSTEM	FL16001
	27C	HOT FLARE WITH IGNITION SYSTEM	FL16002
	28	LNG DRAIN KO DRUM	V16000
	29	HEAVY HC KO DRUM	V16200
	30A	THERMAL OXIDIZER	IN16200
	30B	THERMAL OXIDIZER – CHIMNEY	–
LNG STORAGE AND TRUCK LOADING	31A/B	LIN STORAGE TANKS (EXCLUDED FROM SCOPE OF SUPPLY)	VT17000/17001
	32A/B	LIN BUILD-UP VAPORIZERS (EXCLUDED FROM SCOPE OF SUPPLY)	E17000/17001
	33	NITROGEN BACK-UP MODULE NITROGEN BACK-UP TRIM HEATER	MDL17000 H17000
	34A/B	LIN BACK-UP VAPORIZERS	E17002A/B
	35	LNG TANK MODULE	MDL19000
	36A/B	LNG STORAGE TANKS	VT19000/19001
	37	LNG BUILD-UP VAPORIZER	E19000
	38A/B	LNG TRUCK LOADING PUMPS	P19000/19001
	39A/B	TRUCK LOADING BAY	TL19000/19001
	47A/B	TRUCK SCALE	–
ELEC. AND AUTOM. SYSTEM	40	MV DISTRIBUTION CONTAINER	–
	41	TRAFO CONTAINER MV/MV TRANSFORMER MV/LV TRANSFORMER	– +T1 +T2
	42	LV DISTRIBUTION CONTAINER	–
	43	LCR CONTAINER	–
	44	–	–
	45	–	–
	46A	DIESEL EMERGENCY GENERATOR	–
	46B	DIESEL EMERGENCY GENERATOR – CHIMNEY	–
	48	ANALYSIS CABIN	–
	49	CONTAINER FOR DRIVER REST (EXCLUDED FROM SCOPE OF SUPPLY)	–