LOSS PREVENTION PROTECTION PHILOSPOHY

U100 HTDC

Site	HTDC
Shin-Etsu Doc. No.	4.111.228

Please destroy any previous issues

Rev	Description	Date	Made	Checked	Approved
A	Issued for Client Review	17FEB21	2E		
B	Issued for Design	4MAR21			
			5-MAR-2021	08-MAR-2021	08 Mar '21

- This document is issued by Fluor ("Fluor") for Shin-Etsu PVC ("Company") and forms part of the performance of Fluor's engineering services in accordance with the FEED Contract for the HTDC and Line 7 Project.

Table of Contents

Revision Description

Revision	Description
A	Issued for Client Comments
B	Incorporated client comments received the 3rd of March

Abbreviations

Abbreviation	Meaning
EDC	Ethylene Dichloride
HL	Hazard Level
HTDC	High Temperature Direct Chlorination
IDLH	Immediate Danger to Life and Health
PA	Public Address system
PIV	Post Indicator Valve
PPE	Personal Protective Equipment
PSL	Potential Source of Leakage
PVC	Polyvinylcloride
SCBA	Self-Contained Breathing Apparatus
SE	Shin Etsu
VCM	Vinyl Chloride Monomer

1. General

1.1. Introduction

This document describes the fire protection philosophy for the Shin-Etsu PVC BV HTDC project. The current philosophy of Shin Etsu is based on the application of isolation systems, to reduce the potential release of hazardous materials and prevent fire escalation. The intention of the new installation is to follow the current approach.

1.2. Objective

The objective of the fire protection design is to provide adequate firefighting facilities to limit the effects of a fire in the new U100 HTDC facility. The objective as well as the approach to fire protection is provided in the Nouryon Manual [1]. The design of the system will follow the requirements as provided in this manual.

1.3. Scope

The scope of the fire protection specification is limited to the new U100 HTDC facility on site the Botlek Shin Etsu premises. The scope is limited to fireproofing, application of firewater, portable fire extinguishers and safety installation. The scope does not include the additional process equipment on the brownfield scope of the project. The brownfield scope is covered in a separate document.

2. Codes and Standards

Fluor will use industry codes and standards. The project design documents will conform to the latest applicable local codes (NEN), European standards and of the International Electrotechnical Committee (IEC) codes and regulations. In addition to those codes and standards, Fluor will prepare project specific requirements as described in section 2.2.

2.1. Codes and Standards

The following international standards are used for the fire protection systems for the new U100 HTDC unit.

NFPA 13	Standard for Installation of Sprinkler Systems, 2019
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection, 2017
NFPA 16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, 2019
NFPA 20	Standard for the Installation of Stationary Pumps for Fire Protection, 2019
NFPA 24	Standard for the Installation of Private Fire Service Mains and Their Appurtenances, 2019
API 2218	Fireproofing Practices in Petroleum and Petrochemical Processing Plants, 2020
NEN ISO EN 7010	Graphical symbols — Safety Colours and Safety Signs —Registered Safety Signs
NEN 2535	Brandmeldcentrale
NEN EN 54-11	Handbrandmelders
NEN EN 54-2	Brandmeldpaneel

NEN-EN 54-3	Brandalameringsapparatuur
NEN EN 671-3	Draagbare blustoestellen
NEN-EN 54-7	Rookmelders
NEN-EN 54-20	Aspiratie rookmelders
NEN 2559	Onderhoud van draagbare blustoestellen, 2001
NEN 4001	Brandbeveiliging - Projectering van draagbare en verrijdbare blustoestellen
EN 61936-1: 2010+A1:2014	Power installations exceeding 1 kV a.c Part 1: Common rules
prEN 15154-5	Emergency Showers- Part 5: Water overhead body showers for Sites other than Laboratories, May 2018 (Draft)
EN 15154-2	Emergency Safety Showers- Part 2: Plumbed-in Eye Wash Units, Sep 2006.
IEC 60079-0	Electrical Apparatus for Explosive Gas Atmospheres
2014/34/EU	ATEX Directive
2014/30/EU	EMC Directive
2006/95/EC	LY Directive
2006/42/EC	Machine Directive

2.2. Specifications

The following Specifications, Shin Etsu/Nouryon and project standards were used for the development of the fire protection specification.

A8XN-HTDC-653-RPT-001-00020	Zone indeling VCB
A8XN-HTDC-225-DBD-001-00002	Site and Utility Data
A8XN-HTDC-653-PHL-001-00001	HSE Memorandum
2.462.426	Nouryon Manual, Documentnumber Fire, Fire prevention and firefighting, August 19th, 2015.
	Bedrijfsbrandweerrapport, Bedrijvenpark Botlek Procedure, Versiedatum: 26-Apr-2017

3. Environmental Data

For details on the environmental data, refer to specification A8XN-HTDC-225-DBD-001-00002 Site and Utility Data

4. Hazardous Area Classification

All applied new materials, installations, equipment and components within plant/unit boundaries shall at least be compliant with the applicable European and local standards.(e.g. ATEX, NEN-EN). Field detectors will be located outdoors within a hazardous area. Refer to A8XN-HTDC-653-RPT-001-00020 Zone Indeling VCB. The area classification for the new HTDC unit is provided on HAC drawings A8XN-HTDC-653-SKT-001-00020 and A8XN-HTDC-653-SKT-001-00021. In general electrical equipment inside the HTDC shall comply with the requirements for Zone 2 Gas Group IIB and T-Class T1 for areas containing ethylene Gas Group IIA and T-Class T2 for all other areas.

5. Scope Fire Protection

The events where the fire protection system will have to cope with are provided in the HSE Memorandum [2]. These events are:

- Liquid pool fire
- Jet fire
- Toxic vapour cloud
- Electrical fire

5.1. Liquid Pool Fire

Pool fires can occur when flammable products are released from process equipment. Ignition of the vapour will lead to a spread of the fire over the surface of the pool. The main product in the U100 HTDC is EDC (Ethylene Dichloride). In some of the equipment the mixtures are heated above the atmospheric boiling point, hence a part of the released liquid will flash-out immediately. In almost all release scenarios the liquid is heated above the flash point of EDC. Although EDC is not ignited easily a strong ignition source might cause a fire. Assuming the pool will be collected below the equipment, the pool fire will be on the solid floor below. EDC has a low energy content (ΔHc = 12155 kJ/kg) compared to normal hydrocarbons of similar molecular weight. Due to the low combustion heat the burning rate as well as the surface emissive power is lower than pool fires of hydrocarbons.

Isolate the affected equipment and reduce the amount of fuel is the applied strategy to limit the duration of a pool fire. Containing the fire within the curbs of the unit and drain the liquid as fast as possible will reduce the area of the pool fire and with that also the damage radius. Unprotected steel and equipment will be lost when exposed the 100 kW/m² or more heat radiation [3]. Process equipment exposed to heat radiation more than 35 kW/m² will fail rapidly if not cooled or fireproofing is applied [3]. Extinguishing the fire as well as the cooling of exposed equipment will be the main strategy for suppressing the consequences of pool fires [1]. For the purpose of approach to the fire a typical pool fire for the U100 HTDC is modelled for weather category 5D. The heat contours of interest are:

- Heat radiation with potential for equipment failure after prolonged exposure (q=35 kW/m²)
- Short term heat radiation exposure to personnel (without bunker gear) (q=10 kW/m²)
- Long term heat radiation allowed by fire brigade (with bunker gear) (q=3 kW/m²)

The wind direction and speed plays an important role in the safe distance to the heat source. The size of the liquid pool determines the burning rate as well as the heat radiation contours. The slope of the process floor is used to remove the liquid spill as fast as possible; hence reducing the size of the pool. The fire protection design is based on credible scenarios. Leakages are assumed based on a leak size of 0.1xD of the connection pipelines. Catastrophic rupture of vessels and drums is not anticipated for in the design. These incidents is immediately scaled up to an escalated fire, requiring major accident response by the fire brigade. The maximum quantity released is equal to the inventory of the emergency isolation system (insluitsysteem).

Fire extinguishers, used in the incipient stage and the fixed firewater monitors used during the first phase (credible scenario) of the fire can be safely operated considering the location. For firefighting of escalated fires, the high capacity long reach firewater monitors of the fire brigade and the protective clothing of the fire responders can ensure sufficient distance with limited exposure to the fire's heat radiation.

The combustion of EDC will generate Hydrogen Chloride fumes. Exposure to these fumes will have adverse effect of long tissue when inhaled or cause severe burns to skin and eyes. As the concentration of Hydrogen Chloride will be high, the approachability of a pool fire will be difficult for personnel not equipped with the appropriate PPE. Dispersion of Hydrogen Chloride to atmosphere will cause acid rain down in the area downwind the pool fire.

5.2. Jet Fire

As the pressure inside process equipment is low and the combustion energy and required ignition energy do not support jet fires of EDC from the process equipment. Jet fire scenario is possible for the ethylene supply line. Ethylene is a highly flammable gas and easily ignited. The supply pressure of ethylene to the unit is 58.9 barg and reduced to after the pressure controller to 40 barg before expanded to the pressure of the AR-130 HTDC Reactor before entry. Leakage at this pressure provide considerable length of jet fires. Impinged equipment is exposed to very high temperatures. Unwetted equipment and unprotected load baring steel will fail rapidly and might initiate fire escalation when the inventory is combustible. The main strategy for jet fire is the shutoff the fuel and depressurize the system. Cooling is provided for impinged equipment and structures by applying firewater directly on the exposed area. The jet fire is not extinguished until the pressure in the system is reduced to atmospheric to prevent the formation of an explosive cloud. Once the pressure is reduced sufficiently the jet fire is extinguished with fire water spray or powder applied to the leak area.

5.3. Toxic Vapour Cloud

5.3.1. Chlorine

Chorine gas is supplied at 9.8 barg to the AR-130 HTDC Reactor and the AR-160 Reflux Chlorinator and reduced to 1 barg after the pressure controller. Chlorine gas is heavier than air and will disperse to grade when released. Chlorine dissolves slightly in water (7.9 g/l). Knocking down chlorine vapour cloud is possible using water spray from fixed fire water monitors [5]. However the water containing chlorine should not be discharged directly to the biological water treatment. Chlorine will have a detrimental effect on the bacteria. The spent water should be collected and treated separately in the CRWS. The waste water is injected with pH-controlled caustic and transferred to C-252 before treated in the biological water treatment unit.

5.3.2. Combustion Products

Organic chloride combustion products will contain high concentrations of Hydrogen Chloride (see 5.1).

5.4. Electrical Fire

The substation and analyser house on the U100 HTDC plot can be subject to an electrical fire inside switch gear and cabinets. Failure of electrical components that lead to fire are:

- Mechanical failure of electrical components
- Electric arc between parts with high voltage differences
- Component overload

The temperature in an electric arc is far beyond the ignition temperature of the plastic components and cables. Failure of electrical component is a common cause for fire inside substations. In addition a fire inside the cabinets or below the false floor will cause severe damage due to heat and smoke. Deposition of carbon might short-circuit other electrical components and escalate the fire to other parts of the building.

6. Firewater Supply

The fire protection systems are shared with neighbouring companies on the same premises. A description of the fire protection system is described in the Brandveiligheidsrapport [5].

6.1. Firewater Storage

The firewater is stored in the firewater tank T3702 with a capacity of 3200 m³ of potable water. The tank is supplied with potable water from a DN300 pipe line, which is connected to the public potable water grid.

6.2. Firewater Pumps

6.2.1. Main Firewater Pumps

The design of the firewater pumps are based on NFPA 20. The firewater to the grid is supplied by three (3) diesel driven firewater pumps (P3704A/B/C) with a capacity of 600 m³/hr each at 10 barg. The pressure inside the firewater grid is maintained at 10 barg by a jockey pump, P3705, with a capacity of 100 m³/hr. The firewater pumps are started automatically on pressure loss. When the pressure drops below 9.5 barg, the first firewater pump P3704A is started automatically. The second pump P3704B is started when the first pump cannot maintain the pressure and the pressure drops to 9 barg. The third pump is automatically started when the pressure drops below the 8.5 barg. The firewater is diverted back to the firewater storage tank T3702 with two (2) circulation relief valves. When the pressure exceeds 10.5 barg the first circulation valve is opened. If the pressure is still increasing, the second circulation valve is opened at 12.4 barg. The pumps can also start manually.

6.2.2. Back-Up Firewater Pumps

When the firewater pumps P3704A/B/C do not start or the firewater demand exceeds the combined capacity, additional back-up firewater pumps are started. These pumps are located at the Zoutsteiger at the harbour side of the facility. The vertical shaft pumps P3701A/B are electrical driven and have capacity 500 m³/hr each at 10 barg. The first pump P3701A start automatically when the pressure in the firewater grid drops below 4 barg and the second pump P3701B at 2.5 barg. The pumps supply brackish water from the harbour to the firewater grid. The start of the pumps is alarmed inside the control room E&U, VCB and the gatehouse.

6.2.3. Firefighting Tug

A connection to the firewater grid is provided at the jetty for a firefighting tug. For major fires additional fire water can be provided. The connection of the firefighting tug complies with the requirements of the operational permit.

6.3. Firewater Grid

The firewater grid extents over the complete premises of the Bedrijvenpark Botlek. The materials of the fire water lines are partly carbon steel and GRE and vary in size DN400 to DN150. The carbon steel pipelines are insulated with cement. The pipelines are buried below the frost line and are provided with PIVs to sectionalize the firewater grid in case of maintenance. The units of Shin Etsu in the Botlek are supplied with firewater from at least 2 sides. The firewater grid supplies hydrants, monitors, hose reels and deluge systems with firewater. The pressure inside the firewater grid is safeguarded with 2 pressure relief valves, with set pressure of 15.8 barg.

6.4. Fixed Firefighting Systems

Hydrants and monitors are located at strategic locations to around the units on site the facility. The location of the hydrants and monitors is provided in the drawing (Aanvalsplan).

- Existing hydrants have a hydraulic capacity between 2400 lpm and 6000 lpm at 10 barg.
- Fixed fire water monitors have a capacity of 2400 lpm and throw length between 40 and 45 meter
- Some fixed fire water monitors have a foam pick-up system
- Fire hoses have a standard length of 20 meter.
- Deluge systems are provided for selected sections of the existing units

6.5. Firewater Drainage and Collection

Spent firewater in the process area is collected on impermeable floors and discharged to the Contaminated 2E Sewer (CRWS) system and pumped to the dirty water collection tanks T2501/2. The capacity of the storage tanks is 3700 m³ and sufficient to collect at least 1 hour of the maximum fire water demand of 2800 m³/hr. The dirty water is treated in the Steam Stripper C252 and discharged to the biological water treatment. After biological treatment the water is discharged to the harbour.

7. Credible Scenarios

The design of the protective systems will be based on credible scenarios. Credible scenarios are based on experience and might happen during the lifetime of the unit. Credible scenarios are provided for:

1. Pool fires
2. Jet fires
3. Toxic vapour clouds

7.1. Credible Pool fire

The fire scenario development will be the basis for the loss prevention design with respect to the active and passive fire protection. The design shall be based on a credible fire scenario, considering size and likelihood. The determine the credible fire scenario the following is assessed:

1. Hazardous product inventories of the U100 HTDC unit
2. Containment, drainage on compartments
3. Credible size
4. Fire scenario development
5. Fire duration

7.1.1. Hazardous Product Inventories

The main hazard for fireproofing is liquid pool fire. The U100 HTDC process unit is divided in emergency isolation systems (insluitsystemen). The main liquid content is Ethylene Dichloride (EDC), a flammable liquid under atmospheric conditions. The below table provides the liquid inventory of the emergency isolation systems.

Table 7-1: Emergency isolation system liquid inventories

System	Emergency Isolation System	Hazardous Liquid Inventory[1)] [m³]	Average Pressure [barg]	Average Temperature [°C]
1	Air compression	Only air	13.0	10.0
2	Ethylene supply	No liquid	36.8	74.1
3	Chlorine supply	No liquid	4.4	40.0
4	Receiver tank	32.9	2.4	128.2
5	HTDC Reactor/Distillation	93.1	3.1	108.0
6	Chemical dosing	< 5	2.4	128.2
7	LP Steam	Not hazardous	-	-
8	EDC Discharge	Pipe line	3.1	131.2
9	Propylene chiller liquid	Supply and return	0.74	-35.0
10	Recycle EDC Purification	37.4	0.8	72.3
11	Recycle EDC Reboiler Steam	Not hazardous		
12	Tempered water system	Not hazardous		

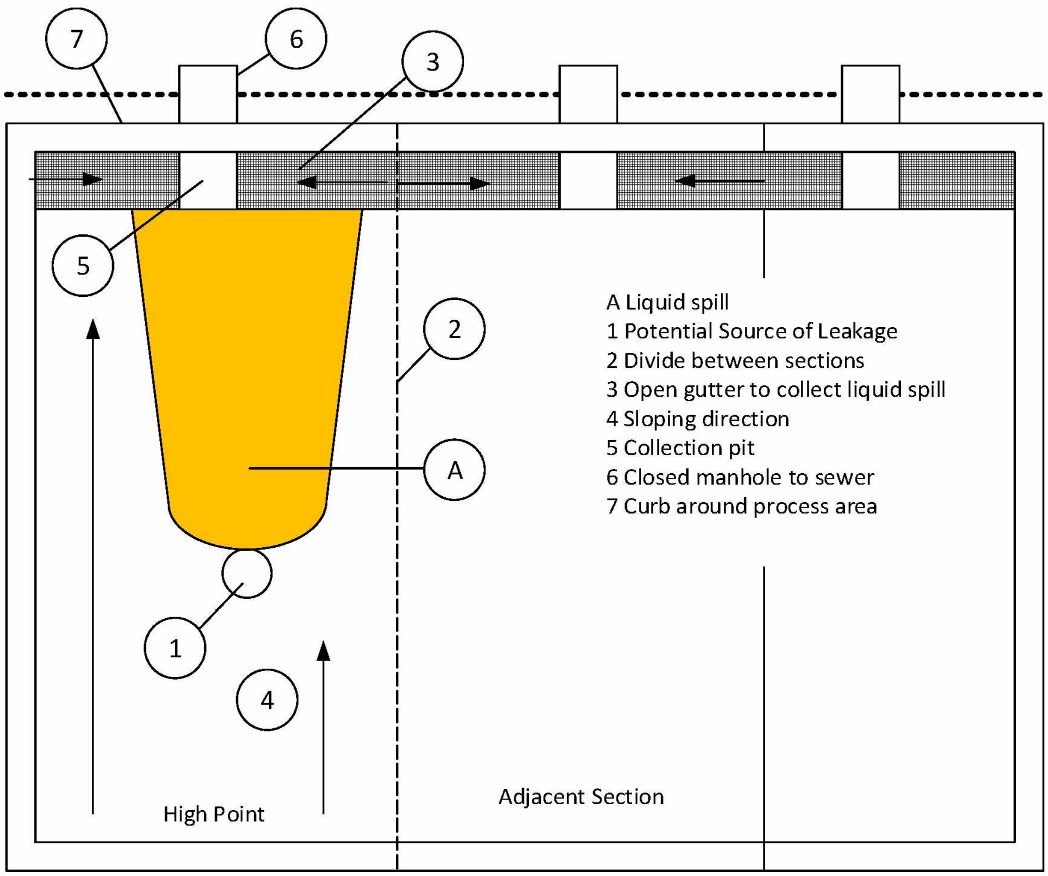
1) Based on HHL of the equipment as per datasheet

The pressure inside the systems is relatively low. Temperatures of the HTDC Reactor system are elevated to above the atmospheric boiling point of EDC. EDC is the main flammable product inside the systems. Most releases will flash-out in a vapour and liquid.

7.1.2. Containment, Drainage and Compartments

The process equipment is located above a liquid impervious floor with curbs and drain facilities. The floor is sloped towards a gutter, which is connected to an underground manhole (Figure 7-1). The design capacity of the drainage is equal to the expected firewater demand of 135 m³/hr (=38 kg/s) per section. The size of the pool is therefore limited to the travel distance from the leak source towards the drain gutter in the section of the unit.

Figure 7-1: Liquid pool inside process area



When the leakage rate exceeds the design capacity of the compartment's drain system, the liquid pool will overflow to the adjacent section of the drain system. Only the gutter is affected. Therefore the pool size will remain the same.

7.1.3. Pool Size

The slope of the floor determines the size of the pool. The pool size follows the Manning equation [7][8]. The lateral spread of the liquid is initially determined by the gravity. However as the thickness of the liquid layer decreases, the lateral flow is limited by the resistance of the roughness of the concrete floor. This will shape the form of the pool. Depending on the slope of the floor and the travel distance in the direction of the slope, the area will be:

Table 7-2: Slope and area (Q=8.15 kg/s)

Slope	Pool Area for Travel Distance to Gutter					
	4 m	6 m	8 m	10 m	12m	14 m
[%]	[m²]	[m²]	[m]	[m²]	[m²]	[m²]
0.5	3.1	15.4	32.6	52.3	74.7	96.0
1.0	3.1	10.4	21.7	35.0	49.9	64.3
2.0	2.9	8.6	16.7	26.3	36.9	47.2
3.0	2.8	7.8	14.7	22.6	31.5	40.0
5.0	2.8	7.2	12.7	19.2	26.2	33.1

The leakage rate has a minor effect on the shape and total area of the pool [8]. The floor will be sloped 2%. The travel distance of a pool on the process area is approximately 12 meter from the PSL over the HL towards the drain gutter. The expected size of the pool area will be 37 m² (see Table 7-2).

7.1.4. Fire Scenario Development

The consequence analysis [4] considers pool fires based on the release of Ethylene Dichloride (EDC). EDC is the main flammable liquid in the U100 HTDC. As the unit operates on a relatively low pressure (1 – 8.5 barg) the leakage rate is low. In addition EDC has a low heat of combustion compared with normal hydrocarbons of the same molecular weight, which results is a low burning rate of 0.04 kg/s.m²; hence the surface emissive power and heat radiation are lower if compared with a normal hydrocarbon pool fire. The heat radiation more than 35 kW/m² is almost at the edge of the pool. Only equipment impinged by flames receives higher heat input. The following table provides the leak size of major equipment in the different sections of the U100 HTDC unit and the heat radiation from the pool fire.

Table 7-3: Leakage of major equipment with pool size of 37 m² (hydraulic diameter = 6.86 m)

Equipment	Leak Size1)	Leak Rate	Flame Length	Heat Radiation2)			Leak Duration
				3 kW/m²	10 kW/m²	35 kW/m²	
	[mm]	[kg/s]	[m]	[m]	[m]	[m]	[hrs]
AR-130	25	8.15	9.8	16.8	9.6	5.8	0.38
AS-130	30	10.23	9.8	16.7	9.5	5.8	2.10
AC-140	25	4.62	9.8	16.7	9.5	5.8	0.73
AC-160	40	11.76	9.8	16.6	9.4	5.8	1.06
AS-160	20	1.94	9.8	16.7	9.4	5.8	10.3

1) Leak size is based om 0.1D of the major pipe line
2) Distance from centre of the pool

Pumps are provided with sophisticated seal systems. The scenarios are inserted on the plot plan to assess the potential damage to the adjacent equipment and structures. The contours are included in Appendix A.

The following table provides the effected equipment in the 35 kW/m²-contour at grade level.

Table 7-4: Equipment inside pool fire scenario (elevation < 10m)

Pool Fire	Equipment in Heat Radiation Contour								
	3kW/m² - 10 kW/m²			10 W/m² - 35 kW/m²			>35 kW/m²		
	Pumps	Vessels Drums HX	Columns Reactors	Pumps	Vessels Drums HX	Columns Reactors	Pumps	Vessels Drums HX	Columns Reactors
AR-130	AP-142A	AT-130		AP-132	AH-130A		AP-130A	AH-133	
	AP-142B	AH-133		AP-140B	AH-130B		AP-130B		
	AP-161A				AS-130		AP-131		
	AP-161B						AP-140A		
AS-130	AP-130A	AH-130A	AC-140	AP-130B	AS-140	AR-130		AH-133	
	AP-131	AH-130B		AP-140A	AH-143	AT-131			
	AP-132	AH-132		AP-140B					
	AP-161A			AP-142A					
	AP-161B			AP-142B					
AC-140	AK-140	AS-130					AP-141A	AH-143	
	AP-140B						AP-141B	AH-145	
	AP-142A						AP-143A	AH-146	
	AP-142B						AP-143B		
	AP-147A								
	AP-147B								
AC-160	AP-160A	AH-160	AR-160	P-3331A	AH-163			AH-161	
	AP-160B			P-3331B	AS-160				
	AP-161A				V-3331				
	AP-161B								
AS-160	P-3331A	AH-161		AP-160A	AH-160	AC-160			
				AP-160B	AH-163	AR-160			

Equipment and structures within the 35 kW/m² contour are prone to failure when no cooling during a fire is provided or fireproofing applied. If cooling by fire monitor or deluge system cannot be provided, the equipment (excluding pumps and compressors) and structure requires fireproofing (refer to Chapter 8).

7.1.5. Duration

The duration of the fire is determined by the liquid volume of the emergency isolation system and the leakage rate. However, small fires of EDC will be easily extinguished using portable extinguishers or fixed fire water monitors. As per Bedrijfsbrandweerrapport [5] active fire fighting can commence 6 minutes after the incident occurring by first responders and 12 minutes by the fire brigade. Considering the size of the pool and the available firefighting equipment the expected duration for extinguishing the fire will be 15 – 30 minutes. The duration of the fire between ignition and extinguishment is set to 40 minutes.

7.2. Credible Jet Fire Scenario

In addition to the pool fire scenario, there is a risk of jet fires in the U100 HTDC unit. Determining the potential scenario for jet fires the following assessed:

1. Hazardous inventories
2. Credible size
3. Jet fire impact

7.2.1. Hazardous Inventories

The AR-130 HTDC Reactor is supplied with ethylene from Nouryon. The initial pressure of 59.8 barg and is reduced 14.7 respectively to 2.5 barg in the AR-130 reactor. Unreacted ethylene is distributed over the various process equipment inside the unit. However the pressure after the initial expansion remains low.

Table 7-5: Emergency isolation systems gaseous inventories

System	Emergency Isolation System	Hazardous Gaseous Inventory1) [m³]	Average Pressure [barg]	Average Temperature [°C]
1	Air compression	Only air	13.0	10.0
2	Ethylene supply	Supply line only	58.9	10
3	Chlorine supply	Supply line only	9.8	40
4	Receiver tank	15,9	2.4	128.2
5	HTDC Reactor/Destillation	186	3.1	108.0
6	Chemical dosing	< 5	2.4	128.2
7	LP Steam	Not hazardous	-	-
8	EDC Discharge	Pipe line	3.1	131.2
9	Propylene chiller liquid	Supply and return	0.74	-35.0
10	Recycle EDC Purification	517	0.8	72.3
11	Recycle EDC Reboiler Steam	Not hazardous	-	-
12	Tempered water system	Not hazardous	-	-

As the conversion of ethylene and chlorine to EDC is very high, the vapors after AR-130 HTDC Reactor contains mostly EDC and low concentrations of ethylene. As the heat of combustion of EDC is low and the pressure is relatively low, the heat radiation as well as the temperature of a jet fire is low compared to similar hydrocarbon jet fires. Only a jet fire originating from the ethylene supply line can cause major damage to equipment and structure.

7.2.2. Credible Size

Leak of the ethylene supply line is set to 0.1D. The ethylene from Nouryon is supplied with a 4" pipe line. The leak size for the high pressure section is set to 10 mm. As the supply line to the AR-130 HTDC Reactor is 6", the orifice of the leak is set to 15 mm.

7.2.3. Jet Fire Impact

Jet fire from a leak in the ethylene supply originates from a 0.1D hole size at a flange connection. The jet fire has the following properties:

Table 7-6: Ethylene jet fire from supply (weather category 5D)

Pipe Line Pressure	Leak Size[1]	Leak Rate	Flame Length	Heat Radiation[2]			Leak Duration
				3 kW/m²	10 kW/m²	35 kW/m²	
[barg]	[mm]	[kg/s]	[m]	[m]	[m]	[m]	[hrs]
59.8	10	0.99	13.95	16.1	13.7	11.7	0.5
14.7	15	0.50	8.18	10.5	9.2	5.7	0.5

1) Leak size is based on 0.1D
2) Heat radiation from the surface of the flame

All equipment and structures in range of the flame length is prone to failure. The duration depends on the time to detect the fire, the time to close the isolation valve in the supply line and the time needed to reduce the pressure to almost atmospheric. As the volume of the pipeline between the isolation valve and control valve to the AR-130 HTDC Reactor is low, the majority of the duration is caused by the detection and action needed to close the isolation valve. As there is no automatic detection nor automatic isolation, the duration is set to 30 minutes.

7.3. Credible Toxic Vapor Cloud

The U100 HTDC unit is supplied with Chlorine gas from the Nouryon grid. In the unit Chlorine is converted to EDC. One of the byproducts is Hydrogen Chloride gas. Both Chlorine and Hydrogen Chloride have toxic properties and have adverse effects on skin and lung tissue when exposed to human.

7.3.1. Toxic Inventories

In the A8XN-HTDC-653-PHL-001-00001 HSE Memorandum substances are identified as toxic. Of the identified toxic substances only Chlorine and Hydrogen Chloride are in hazardous concentrations present to inflict adverse effects. The process equipment were hazardous concentrations are present are included in the following table:

Table 7-7: Equipment with hazardous concentrations toxic and corrosive vapours

Equipment Tag	Description	Process Conditions		Composition	
		p [barg]	T [^{o}C]	Cl2 [vol%]	HCl [vol%]
AR-130	Supply AR-130	4.4	40	99	-
AH-143	HTDC Vent cooler	2.0	66	-	3.8
AH-144	Vent Gas Chiller	1.9	43	-	4.3
AH-146	Vent Gas Discharge Cooler	1.8	-10	-	4.6
AS-140	HTDC Purification Column Reflux Drum	2.0	66	-	3.8
AS-142	Cold Vent Separator	1.8	-10	-	1.1
AK-140	Vent Gas Compressor	7.4	40	-	4.6
AR-160	Supply AR-160	9.8	20	99	-

Chlorine is only present in the supply to the reactors. As soon as the Chlorine gas is introduced in the reactor the concentrations drop considerably to non hazardous levels. The equipment with the high concentration of Hydrogen Chloride is mainly the vent gas system. The vapour phase inside the main equipment of the vent gas system is low (V_{vapor}=3.5 m³ excluding pipe lines and heat exchangers); hence the main hazard occurs during normal operation. Once isolated the release rate will diminish rapidly.

7.3.2. Toxic Vapour Cloud

Hydrogen Chloride and Chlorine gas are the main toxic substances in the U100 HTDC unit. The legal limit values are provided in the following table:

Table 7-8: Toxic Properties and Threshold Values

Substance	#CAS-Number	Limit Value			
		TLV-TWG[1)] [mg/m³]	IDLH [ppm]	ERPG-2 [ppm]	LC50 [ppm]
Hydrogen Chloride (HCl)	7647-01-0	8	50	20	3124
Chlorine (Cl2)	7782-50-5	1.5	10	3	293

1) SER Grenswaarden database

The limit value for the toxic cloud is the IDLH concentration for the vapors. Personnel exposed to these concentrations are still able to evacuate the affected area. The major release cases are the Chlorine supply line and leakage in the discharge of the AK-140 Vent Gas Compressor. The vapor cloud dispersed to atmosphere from the leakage is included in Table 7-9:

Table 7-9: Toxic vapour cloud dispersion major toxic releases (weather category 5D)

Emergency Isolation System	Pressure [barg]	Temperature [°C]	Leak Size[1)] [mm]	Release Rate [kg/s]	Distance IDLH [m]
Chlorine supply	9.8	40	25	13.6	1180
AK-140 Vent Gas Compressor	7.8	40	10	0.13	60

1) Leak size based on 0.1D

Due to the composition of the gas and process conditions in the supply lines of Chlorine gas to the AR-130 and AR-160, a hazardous release of Chlorine gas will be the major risk of the U100 HTDC unit. Approach by incident responders into the hazard zone is only possible using special PPE and SCBA's. All other personnel should remain indoors or be evacuated out of the hazard zone immediately.

8. Protection Design

The loss prevention design will cover those mitigation and repression measures included in the design of the U100 HTDC unit. This will include:

1. Passive fire protection
2. Active fire protection
3. Safety Showers
4. Personal protection

8.1. Passive Fire Protection

Passive fire protection design is based on API 2218:2020. The extend of the fireproofing is based on the assessed fire hazard. This chapter follows the prescribed steps from the API to determine the size of the fire envelope and the applied fireproofing. The methodology includes:

1. Determine liquid inventories
2. Assessment of the fire potential of equipment
3. Define the fire envelope
4. Needs analysis
5. Define extent of fireproofing
6. Select type and applicable fireproofing materials

2E High Fire Potential Equipment

For the identification of high fire potential equipment the prescribed selection of API 2218:2020 Section 4.2.1.2 is used. Based on these criteria the following equipment are considered high fire potential hazard.

Table 8-1: High fire potential equipment as per API 2218:2020

System	Equipment		Criteria
5	AR-130	HTDC Reactor	e) Exothermic reaction
5	AP-130A/B	HTDC Reactor Circulation Pump	b) Flow flam. liquid > 45 m^3/hr
5	AK-140	Vent Gas Compressor	f) Gas compressor
10	AP-160A/B	Recycle EDC Reflux Pump	b) Flow flam. liquid > 45 m^3/hr
10	AP-161A/B	Recycle EDC Bottom Pump	b) Flow flam. liquid > 45 m^3/hr

The selected high fire potential equipment are inserted in the A8XN-HTDC-653-SKT-001-00010 Fire Hazard Drawings.

8.1.2. Fire Envelope

The fire envelope is a 3 dimensional cylindrical shape with a radius from the Potential Source of Leakage (PSL) and the height from the Hazard Level (HL). The size of the shape is determined by the composition of the liquid released and the flow of the leakage. Considering the sloped floor the size of the pool is limited to 37 m^2 (7.1.2). This pool size will lead to a distance of 6 meter to the 35 kW/m^2 contour and flame height of 10 meter. As the centre of the pool will not be below the PSL an additional distance will be considered. The fire envelope will be:

- Horizontal radius of 9 meter from the Potential Source of Leakage
- Vertical height of 9 meter above the Hazard Level (i.e. grade)

Considering the location of the high fire potential equipment the equipment and structures included in Appendix A are within the fire envelope.

8.1.3. Needs Analysis

The purpose of fireproofing is to prevent fire escalation. Additional fuel to a fire is provided when other equipment fails and release their combustible content to the fire. Fireproofing is required for equipment and load baring structure inside the fire envelope and meets the following requirements:

- The equipment contains heat sensitive products (i.e. Ethylene)
- The process equipment (e.g. vessels, drums, columns, etc.) contains more than 5 m³ of combustible products
- The structure for process equipment which weights more than 10 tons, regardless the content.
- Collapse of the structure will cause unacceptable damage to other sections of the facility.

Systems adequately protected by active fire protection do not require fireproofing.

8.1.4. Fireproofing

Fire proofing will be applied for process equipment support and structural steel inside the fire envelope which will meet the criteria of 8.1.3 and is not sufficiently covered by active fire protection systems. The extend of the fireproofing will follow the requirements of API 2218:2020 Chapter 5. The following shall be considered for:

1. Multi-level equipment structures
2. Pipe rack supports
3. Air fin coolers
4. Column skirts
5. Equipment supports
6. Electrical and instrument cables
7. Emergency valves
8. Vent lines

Considering the size of the pool (see 7.1.3**Error! Reference source not found.**) the potential damage to process equipment and structure will be limited. Fireproofing will be required for escalated fires, which cannot be easily extinguished. Considering the limited liquid inventories of the systems a fire duration of maximum 120 minutes is used to determine the fire rating of fireproofing materials. The following paragraphs provide a summary of the API 2218:2020 Chapter 5 to guide the designer.

8.1.4.1 Multi-level Equipment Structures

Within a fire scenario envelope, if potential collapse of unprotected structures supporting equipment could result in substantial damage to nearby fire potential equipment, fireproofing should be considered for the vertical and horizontal steel members from grade level up to and including the level that is nearest to a 9-meter elevation above hazard level. Bracing will only be included in the fireproofing when these are essential to the structural integrity of the structure.

Fireproofing material can be a combination of reinforced concrete and vermiculite cement liner or vermiculite cement liner alone. The fire rating for the fireproofing shall be 120 minutes.

8.1.4.2 Pipe Rack Supports

Pipe racks inside the fire envelope are fireproofed. This applies for both vertical and horizontal beams. If only one vertical beam is within the fire envelope the corresponding vertical beam should also be fireproofed. The horizontal beams within 9 meter above the hazard level shall also be fireproofed. Special consideration for the vertical beams inside a fire envelope that support air fin coolers (8.1.4.3).

Fireproofing materials can be reinforced concrete or sprayed vermiculite cement liner (refer to Nouryon General Specification 1.778.879 paragraph 2.3.2). The required resistance of the applied fireproofing material shall at least be 120 minutes. Combinations of reinforced concrete and steel protected with fireproofing materials are allowed.

8.1.4.3 Air 2E

The support of air fin coolers placed on top of a pipe rack shall be fireproofed from hazard level (grade) up to the supports of the air fin, regardless the height of the air fin cooler.

Pipe rack is fireproofed as per paragraph 8.1.4.2. Vertical support beam of below the air fin coolers is sprayed with vermiculite cement liner until and including the supports of the air fin cooler.

8.1.4.4 Column Skirts

Column skirts inside a fire envelope shall be fireproofed to maintain the integrity of the column. The inside of the skirt does not require fireproofing when the unsealed openings to the skirt are less than 600 mm in diameter and there are no flanges or valves inside the skirt.

The skirts of the columns inside the fire envelope are fireproofed with Chartec. The applied layer should be sufficient to protect the column for 120 minutes against failure.

8.1.4.5 Equipment Supports

Fireproofing should be considered for steel saddles that support horizontal heat exchangers, coolers, condensers, drums, receivers, separators and accumulators that have a diameter greater than 750 mm and if the narrowest vertical distance between the concrete pier and the shell of the vessel exceeds 300 mm.

Applied fireproofing materials is Chartec. The applied layer should be sufficient to protect the column for 120 minutes against failure.

8.1.4.6 Electrical Power and Instrument Cable

Only cables for instrumentation and power supply to equipment will be fireproofed if they are required to have a safe shutdown the facility during a fire. Fireproofing can be omitted when the equipment returns to a safe state when the signal or the power is lost. Special considerations are required for Emergency Isolation Valves (see 8.1.4.7). Fireproofing is not required for buried cables. Only the aboveground portion of the cables, including junction boxes, inside the fire envelope requires fireproofing.

Applied fireproofing can be boxed trays or wrapped with fire resistant mats (e.g. Pyrogel). Fire rating of the fireproofing material shall be 30 minutes.

8.1.4.7 Emergency Isolation Valves

Emergency isolation valves are port of the emergency isolation systems (insluitsystemen). Emergency isolation valves required to shutdown the fuel to a fire to prevent escalation or mitigate the consequences of a fire. The valves will be fireproofed when:

- The valve is located inside a fire envelope
- The valve needs to be operable during a fire
- The valve is not fail safe (i.e. the valve should return to the safe position when exposed to fire)

Valves are wrapped with fire resistant mats (e.g. Pyrogel). The applied thickness of the wrapped mats should protect the valve for at least 30 minutes. The position indicator of the valve shall be visible after the valve has been wrapped.

8.2. Active Fire Protection

The firewater supply for the active fire protection systems is provided from the existing firewater grid (see Chapter 0). The fire protection system includes the firewater protection system as well as the other active safety systems for fire protection and fire extinguishment. Fireproofing requirements is not included in this specification. The active fire protection system includes:

- Fire water protection systems
  - Hydrants
  - Fixed fire water monitors
  - Water spray systems
- Mobil fire protection systems
  - Portable Fire extinguishers
  - Wheeled fire extinguishers
- Miscellaneous
  - Hose boxes

For this document a split is made between the process area and the on plot buildings.

8.2.1. Connection Existing Fire Water Grid

Refer to A8XN-HTDC-653-PLN-001-00010 Fire Protection Layout Plan

The water based active fire protection systems is supplied with firewater from the existing firewater grid. The existing supply lines are DN200. The location of the PIV's are selected so the firewater can be supplied to the each other side of the ring not isolated for maintenance.

8.2.2. Process Area

8.2.2.1 Fixed Fire Water Protection Equipment

Refer to A8XN-HTDC-653-PLN-001-00010 Fire Protection Layout Plan

SE has specified type and make of the fixed fire water equipment. The following fixed fire water equipment has been specified:

- Hydrants
- Monitor
- Deluge (Sprinkler)

Hydrants

Refer to standard drawing 3.600.122

The hydrants shall be AVK Hydrant 27CA. The distance between fire hydrants shall not be more than 50 meter (Nouryon Manual 2.462.426 Fire, firefighting and prevention, section 4.3.1). The location of the hydrants is included in A8XN-HTDC-653-PLN-001-00010 Fire Protection Layout Drawing. The hydrant shall comply with the requirements of NEN EN 14384 and includes the following:

1. Material of construction shall be cast iron
2. The pressure rating of the hydrant shall be PN16
3. The hydraulic capacity of the hydrant shall not be less than 144 m^3/hour at 10 barg
4. The hydrant shall be of a dry barrel type with bottom valve to prevent freezing during temperatures below 0 ºC
5. The bottom valve is operated with a hand wheel on top of the spindle
6. Hydrants shall be self draining type
7. The hydrant is connected with a DN150 [TBC] flange to the fire water main
8. The hydrant is provided with two (2) brass 2½" PN16 gate valves and 2½ " Storz connections (63 mm x NOK81) for standard fire hoses

9. The hydrant is provided with one (1) 4” pumper Storz connection (110 mm x NOK133) to hook up fire trucks
10. All connections shall be complete with caps and chains
11. The hydrant is painted RED (RAL 3000) to enhance identification
12. Traffic barriers are placed on two sides of the hydrant to prevent damage due to collision

The required numbers of new hydrants is five (5) and are distributed around the plot as per drawing A8XN-HTDC-653-PLN-001-00010. The drawing includes the existing hydrants are located around the area. No changes for these hydrants are included in the scope of the HTDC project.

Monitors

Refer to standard drawing 3.600.122

Firewater monitors are Elkhart Brass Vulcan 8500-03 hand wheel operated. Fixed firewater monitors are located around the unit to provide immediate availability in case of fire or toxic vapour cloud. Fixed monitors shall be connected to the main water network and located near the process equipment to be protected. The monitors are combined with the hydrants. The location shall not be within the 3 kW/m² contour of the pool fire originating from the equipment protected. The firewater monitors shall comply with the following requirements:

1. The monitor is combined with a hydrant. The monitor is connected with the 4” elbow on the side of the hydrant
2. The monitor is connected with a 4” base plate to the hydrant
3. The pressure rating of the monitor shall be not less than PN16
4. The nozzle is made of brass and has a base size of 2½”
5. Fixed water monitors shall have adjustable nozzle for full fog/jet
6. The capacity of the monitor shall not be less than 144 m³/hour at 10 barg
7. The throw of the full water jet shall be in excess of 45 meter at 10 barg
8. Horizontal and vertical movement control shall be manual with hand wheel
    a. Vertical angle of operation in the range 135º
    b. Horizontal movement of 360º
9. Fire monitors shall be of pick up tube type for foam application [TBC]
10. Fire monitors shall be operable manually and it shall be lockable in position to operate unattended if required
11. The monitor is painted RED (RAL 3000) to enhance identification

Water Spray System

Refer to A8XN-HTDC-653-PLN-001-0010 Fire Protection Layout Plan

Equipment prone to fire or located in a fire envelope and not covered by firewater monitors are protected with an automatic fixed water spray systems for immediate cooling and vapour knock-down. Fixed water spray systems shall be provided when the following applies:

- Pumps transferring flammable liquids
- Compressors processing flammable gases
- Process equipment (i.e. vessels, drums, columns, separators) containing more than 10 m³ combustible liquids or vapours located inside a fire envelope AND equipment is not fireproofed AND is not covered with fire water monitors;
- Reactors prone to runaway reaction

For the U100 HTDC unit the following equipment has been selected to provide fixed water spray systems:

Table 8-2: Protected equipment U100 HTDC

DV	Equipment		Covered Area	Spray Density [lpm/m²]
1	AR-130	HTDC Reactor	Bottom 10 m	10
2	AP-130A/B	HTDC Reactor Circulation pump	Base plate + 1 m	10
	AP-131	HTDC Reactor Bottom pump	Base plate + 1 m	10
	AP-132	Catalyst Injection pump	Base plate + 1 m	10
	AP-140A/B	HTDC Sidecut pump	Base plate + 1 m	10
	AP-142A/B	HTDC Purification Column Bottom pump	Base plate + 1 m	10
3	AK-140	Vent Gas Compressor	Base plate + 1 m	10
	AP-141A/B	HTDC Purification Column Reflux pump	Base plate + 1 m	10
	AP-143A/B	Cold Vent Separator Bottoms Pump	Base plate + 1 m	10
4	AP-160A/B	Recycle EDC Column Reflux pump	Base plate + 1 m	10
	AP-161A/B	Recycle EDC Column Bottom pump	Base plate + 1 m	10

Fixed water spray systems are initiated by deluge valves. Refer to P&ID Deluge Manifold (Typical). The deluge valves are located on a header inside a sprinkler building. The sprinkler building is heated to prevent freezing of the water-filled header. The deluge valves are of pneumatic type. The deluge valves are activated based on:

- Loss of pressure in the pilot lines (after heat-sensitive glass bulb / fuse has melted)
- Locally from a push button
- Remotely from the control room

The header is supplied from one single branch of the ring main. The spray density of the water spray systems shall not be less than 10 lpm/m². Large columns are protected from the first 10 meters above the hazard area. The water spray system has to comply with the requirements of NFPA 15. Minimum residual pressure at the spray nozzle for outdoor protection shall be not less than 1.4 bar (NFPA 15 Section 8.1.2). Pressure and demand requirements shall be confirmed with hydraulic calculations as prescribed in Chapter 8 of the NFPA 15. The deluge system shall be certified as per CCV VBB-Brandblussystemen. Certification shall be provided by inspection body accredited according EN ISO/IEC 17020:2012.

8.2.2.2 Mobile Fire Equipment

Refer to A8XN-HTDC-653-PLN-001-00010 Fire Protection Layout Plan

In the process area mobile fire extinguishers are located at strategic point to provide immediate extinguishment of small incipient fires. For the HTDC unit the following mobile equipment will be provided:

1. Portable Fire Extinguishers
2. Wheeled Fire Extinguishers

These mobile fire extinguishers are used to extinguish Class B fires as per NFPA 10 (5.2.2) inside the process area. Class B fires are fires in flammable liquids, combustible liquids, petroleum greases, tars, oils, oil-based paints, solvents, lacquers, alcohols, and flammable gases. Considering the potential size and inventory of the flammable materials the fires are classified as Extra Hazard as per NFPA 10 Section 5.4.1.3.

Portable Fire Extinguishers

The selected size of the portable fire extinguisher shall be as per NEN 4001. Considering the size of potential incipient fires large capacity fire extinguishers shall be provided. For the HTDC project P9 (80-B) extinguishers are selected. The considered fire hazards are:

- Seal and lube oil systems of pumps transferring flammable liquids
- Seal and lube oil systems of compressors
- Filter systems in fire hazardous service
- Catalyst dosing package

Refer to NEN 4001 for the number of fire extinguishers in the area. All extinguishers shall be positioned at a visible and accessible location, which is protected against weather and damage. Preferably they shall be placed next to exits and escape routes. The portable fire extinguishers are placed in cabinets and mounted on support steel or dedicated poles, whichever is available. The cabinets shall be weather proof and painted RED (RAL 3000). The location of the portable fire extinguisher is indicated with a sign compliant with the requirements of NEN ISO EN 7010. The portable fire extinguisher is mounted not more than 1.5 meters above grade or floor.

Inspection and maintenance of the portable fire extinguishers shall be according NEN 2559.

Wheeled Fire Extinguishers

Wheeled fire extinguishers are provided for fire hazards requiring immediate firefighting with high flow rates. Wheeled fire extinguishers have an increased range, compared to the smaller P9 portable extinguishers. For the HTDC wheeled P50 fire extinguishers are provided for:

- Compressors
- Pumps

The wheeled fire extinguishers are located on a strategic location within 30 meters from the protected area (NFPA 10 Section 5.3.2.7). The cover shall be RED (RAL 3000) and the location is indicated with the appropriate safety sign according ISO EN 7010. The wheeled fire extinguishers are covered with a canvas cover for weather protection.

8.2.2.3 2E

Hose boxes are provided on strategic locations in the vicinity of hydrants. The hose box provides equipment for first responders and includes the following:

- 4 off x 25m long x 1½” diameter hose with 2½” couplings
- 2 off 400L/min capacity water branch pipes, jet/spray with 2½” couplings
- 2 off hose coupling spanners
- 2 off collecting and/or dividing tee connectors

The hose box is mounted on free standing poles, is weather proof and painted RED (RAL 3000). The location is indicated with the appropriate sign according ISO EN 7010.

8.2.3. Buildings

The Substation and Analyser House are the only buildings onsite the U100 HTDC plot. The substation is provided with a false floor for cable routing. Adjacent to the substation two high voltage transformers are located. Transformer fires are suppressed using the fire water monitors and fire trucks connected to the fire water grid (see 8.2.2). The instrument section of the building is provided with separate rooms for UPS systems, batteries and for process control. Electrical fires and cable fires are the most likely for the rack rooms and release of flammable Hydrogen for the battery room.

8.2.3.1 Portable Fire Extinguishers

The distribution of portable fire extinguishers is based on NEN 4001. Portable fire extinguishers inside the buildings be suitable for Class C hazards as per NFPA 10. Class C hazards involve fires in electrical live equipment. For the substation as well as the analyser house 5 kg Carbon Dioxide extinguishers are selected to provide first responder capabilities.

Table 8-3: Number of Portable Extinguishers

Building	Room	Extinguisher	Quantity
Substation	HV Switch Gear	CO2-5kg	2
	LV Switch Gear	CO2-5kg	2
Instrument Rack Room		CO2-5kg	2
Analyzer House		CO2-5kg	2

The fire extinguishers are wall mounted inside the substation, UPS and battery room next to the exits. The location of the fire extinguisher is indicated with the appropriate safety sign according NEN ISO EN 7010.

8.2.3.2 Hose Reels

Hose reels are not provided inside the substation, instrument rack room or analyser house due to electrocution hazard of water and live electrical equipment.

8.2.3.3 Clean Agent [TBD]

Gaseous fire suppression systems are required for vital process control systems only. The instrument rack room is dedicated for process control and instrumentation. No gaseous suppression systems will be applied for fire extinguishing.

9. Fire Detection

Fires typically start small and incipient fires can grow into large scale fires. Early detection of a fire enhances the ability to extinguish a fire in the early stages and limit the damage caused by the fire. Fire detection for the U100 HTDC unit includes:

1. Fire detection in the process area
2. Fire detection in the buildings

9.1. Process Area

Pool fires and jet fires are the credible fire scenarios for the process unit. Early detection is preferred to enable adequate response and limit asset damage. Fire detection in the process area includes:

1. Loss of pressure in the pilot lines of the deluge system
2. PA system
3. Portable radio

In addition operators are equipped with portable radio. In case of fire detection the shift supervisor in the control room is alarmed.

9.1.1. Pilot Lines

The deluge system is automatically activated on loss of pressure inside the pilot lines. The pressure in the pilot lines are maintained at 2.8 barg. The pilot line is provided with fusible glass plugs type RED or BLUE, depending the vicinity of hot process equipment. In case of fire the fusible glass plug (type RED or BLUE) will melt when it will reach 68 ºC (RED) respectively 141 ºC (BLUE). Loss of pressure will:

- Initiate a local alarm (water gong);
- Initiate an alarm in the control room;
- Open the deluge valve of the affected area.

The glass fuses are located near the equipment protected by the sprinkler system.

9.1.2. PA System

Throughout the process area a PA module is located for direct communication with the control room. This system is not connected to the F&G panel inside the instrument rack room but is a standalone system.

9.1.3. Portable Radio

Operators are standard equipped with portable radios (Portophone) which allows direct communication with the operator in the control room. Visual detection of fire or other incident can be reported immediately so action can be initiated. The advantage of this system is the operator can report the nature and location of the incident and estimated severity. The use of the portable radio can be out of the hazard zone and is not dependant of a fixed location.

9.2. Buildings

The process buildings in the scope of the HTDC project are unoccupied buildings. These buildings are visited for maintenance purposes by trained and authorized personnel only. The buildings included in the scope of the HTDC project are:

1. Substation
2. Instrument Rack Room
3. Analyzer House
4. Sprinkler Valve Building

Fire detection systems are provided for these buildings when there is a credible risk of fire. Therefore not fire detection is provided for the Sprinkler Valve Building as no combustibles are located inside this building.

9.2.1. Fire Detection

The buildings are is subject to credible fire scenario for switchgear equipment, electrical cabinets, equipment and dry transformers. The fire detection of the buildings includes:

1. Fire alarm control panel
2. Smoke detection
3. Aspirating smoke detection system
4. Manual call points
5. Horns and beacons

Typically the substation is only accessible by authorized personnel and closed off for all others.

9.2.1.1 Fire Alarm Control Panel

Signals from the aspiration smoke detectors, smoke detectors, manual call points are collected in the Fire Alarm Control Panel (FACP) (Brandmeldpaneel), which is shared with the substation. The FACP is connected to the fire alarm panel (Brandmeldcentrale) in the control room. The FACP has to comply with the requirements of NEN EN 54-2. The local FACP:

- Collects the incoming alarm signals from the detectors or manual call points from the buildings
- Provides outgoing alarm to the central fire alarm panel inside the control room
- Activates the horns and beacons near the entrances of the affected building
- Shutdown the ventilation system of the affected building

The location of the FACP is next to the main entrance of the instrument rack room.

9.2.1.2 Smoke Detectors

The buildings are provided with optical [TBC] smoke detection. The smoke detectors are addressable and have to comply with the requirements of NEN-EN 54-7 Rookmelders. The location and placement of the smoke detectors shall be according the spacing requirements of NFPA 72. As the cable cellar for the substation and instrument rack room are closed with fencing, no smoke detectors are required below the false floors. The smoke detectors are wired to the local FACP inside the instrument rack room.

9.2.1.3 Aspirating Smoke Detection System

The instrument rack room is provided with an aspirating smoke detection system to provide very early smoke detection (VESDA). The aspirating smoke detection system has to comply with the requirements of NEN EN 54-20 Aspiratie rookmelders. Air is extracted out of the cabinets [TBC] and transferred to the detection device. In case of detection of smoke, the outgoing signal is wired to the FACP inside the instrument rack room.

9.2.1.4 Manual Call Points

Near the exit of the building a manual call point is provided. Personnel in egress of the building can initiate the alarm by pushing the button, in case the smoke is not (yet) detected by the smoke detectors. The manual call point have to comply with the requirements of NEN EN 54-11 Handbrandmelders. The cable is connected to the FACP inside the instrument rack room and is transferred to the fire control panel in the control room.

9.2.1.5 Horns and Beacons

The FACP initiates the acoustic alarm (horns) and beacons. The horns are located inside the building in the vicinity of the entrances. The beacons are located outside the entrance to the building. The horns and beacons shall comply with the requirements of NEN EN 54-3 Brandalameringsapparatuur. The beacon is stroboscopic and is RED.

9.2.2. Overview

Table 9-1 provides an overview of the number of detectors.

Table 9-1: Overview applied fire detection inside process buildings

Building		Area [m²]	FACP	Smoke Detector	Aspirating Smoke Detector	Manual Call Point	Horns and Beacons
Substation	LV Room	60	-	6	-	2	2
	Transformer T01	9	-	2	-	-	1
	Transformer T02	9	-	2	-	-	1
	False floor	60	-	-	-	-	-
Instrument Rack Room	Cabinet floor	42	1	-	1	2	2
	False floor	42	-	-	-	-	-
Analyzer House		35	-	4	-	1	1

10. Toxic Gas Detection

Refer to A8XN-HTDC-653-SPC-001-00002 Gas Detection Specification.

11. Safety Installation

11.1. Safety Showers and Eyewash Systems

Safety showers and eyewash systems are provided where there is a potential of exposure to hazardous materials. The selection of application and location of safety shower and eyewash system is based on the hazardous substance and activity with potential exposure to the hazardous substance. Hazardous materials are defined as:

- Highly corrosive materials, such as acids, caustic, and other similar materials, classified as Skin Corrosive Category 1A/1B/1C or Eye Damaging Category 1A/1B/1C as per Global Harmonized System adopted in the EU as Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures.
- Non corrosive hot liquids (e.g. Boiler Feed Water).

Safety showers will not be provided for potential exposure to flammable gases only. The following areas can be designated as high risk exposure sources, to materials as indicated in the previous bullets.

- Pumps with corrosive liquids (not applicable for double mechanical seal, sealess or canned pumps),
- Hazardous liquid sample points (not closed systems)
- Hydrogen chloride vapor or Chlorine sample points (not closed systems)
- Areas where frequent online maintenance activity is expected, (e.g. filters) and exposure to hazardous product is possible
- Dosing systems

For the HTDC project these will be used to assess the requirement for the application of safety showers and eyewash facilities. The location for safety showers and eyewash facilities shall be according EN 15154-5 Emergency Showers- Part 5: Water overhead body showers for Sites other than Laboratories, 2019 (Draft) [9] for outdoor locations. Safety showers shall be positioned such that they are accessible within 10 seconds of travel or not more than 15 m away from the potential hazard and preferably near emergency exits. The safety shower shall be on the same elevation, with no stairs or ramps in between the safety shower and the exposure hazard.

The safety shower shall be of the self-contained type with reservoir on top and connected to the potable water supply to ensure automatic refill. Potential exposure sources are included in Table 11-1.

Table 11-1: Potential Exposure Sources Requiring Safety Shower Eye Wash Systems

Equipment		Phase	Hazardous Substance
AR-130	HTDC Reactor	G	Chlorine
AM-131	Catalyst preparation	L	Hot liquid
AS-140	HTDC Purification Column Reflux Drum	G	Hydrogen Chloride
AH-143	Vent Gas Cooler	G	Hydrogen Chloride
AS-142	Cold Vent Separator	G	Hydrogen Chloride
AK-140	Vent Gas Compressor	G	Hydrogen Chloride
AR-160	Chlorinator	G	Chlorine
AP-130A/B	HTDC Reactor Circulation Pump	L	Hot liquid
AP-131A/B	HTDC Reactor Bottom Pump	L	Hot liquid
AP-140A/B	HTDC Purification Column Side Cut Pump	L	Hot liquid
AP-141A/B	HTDC Purification Column Reflux Pump	L	Hot liquid
AP-142A/B	HTDC Purification Column Bottom Pump	L	Hot liquid
AK-140	Vent Gas Compressor	G	Hydrogen Chloride
AP-161A/B	Recycle EDC Bottom Pump	L	Hot liquid

The safety showers/eye wash system shall be Hughes Safety Showers type EXP-MH-14KS/1500. The safety shower system is temperature controlled. The temperature of the water inside the system shall not exceed 35 °C.

Final location of the safety shower and eyewash shall be confirmed during the 3D Model reviews, when all possible obstructions of the path from the potential source of exposure to the shower are included in the model.

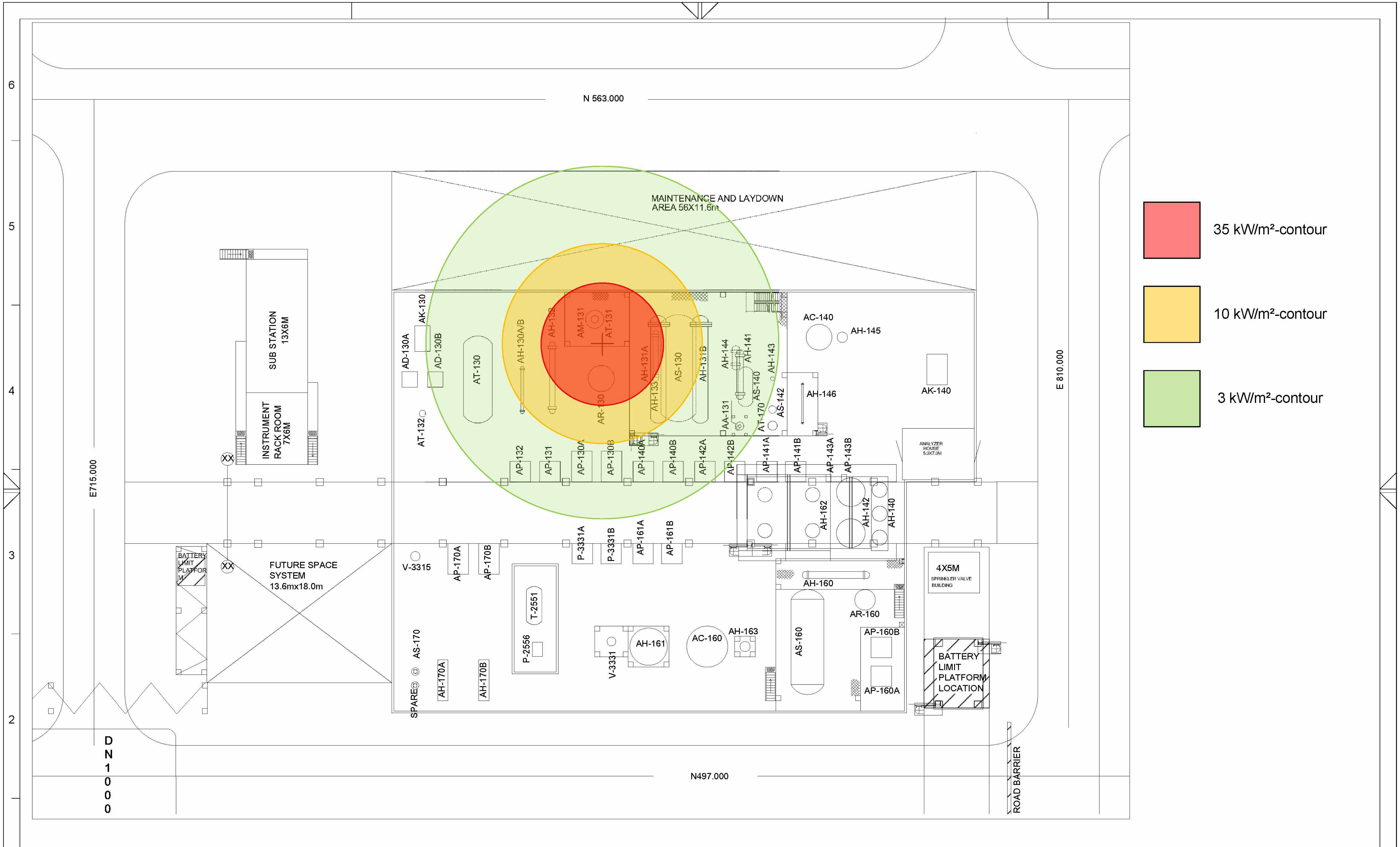
11.2. Hazardous Surfaces

Equipment and pipe lines operated at temperatures below -20 ºC or above 55 °C and which are not insulated shall be protected when they can be reached from grade or platform. Process streams operating below -20 ºC or above 55 °C are indicated in the Process Stream Classification. However if the hot surface is in reach can only be confirmed during the 3D model reviews. When exposure is confirmed the hot surface shall be shielded either by insulation or with a mesh, when insulation is for process reasons not an option.

12. References

[1] Nouryon Manual, Document number 2.462.426 Fire, Fire prevention and firefighting, August 19th, 2015.
[2] A8XN-HTDC-653-PHL-001-00001_RB_IFD HSE Memorandum, January 6th, 2021.
[3] PGS 1:2005 deel 1B: Effecten van brand op constructies
[4] A8XN-HTDC-653-RPT-001-00010 Consequence Analysis, Greenfield plot U100
[5] Bedrijfsbrandweerrapport, Bedrijvenpark Botlek Procedure, Versiedatum: 26-Apr-2017
[6] OTI 92 597 Behaviour of Oil and Gas Fires in the Presence of Confinement and Obsticles, Prepared by The Steel Construction Institute for the UK Health and Safety Executive, 1992.
[7] MDPI [redacted] [redacted] et al, Estimating the Infiltration Area for Concentrated Stormwater Spreading over Grassed and Other Slopes, 6th of September 2018.
[8] Pacific Northwest [redacted] et al, Spills on Flat Inclined Pavements, March 2004.
[9] EN 15154-5 Emergency Showers- Part 5: Water overhead body showers for Sites other than Laboratories, 2019.
[10] EN 15154-2 Emergency Safety Showers- Part 2: Plumbed-in Eye Wash Units, Sep 2006.

Appendix A Pool Fire Heat Radiation Contours



052		100			A3		
fact.no.	fact.dpt	→ processgr./-unit	→ itemcode/tag no.	project no.	size	higher reference doc. no.	part no

title: Heat Radiation 2E Fire
AR-130 HTDC Reactor

fact./fact.dept: Shin-Etsu VCM bv
project: HTDC Project

rev	date	by	dept.	ckd
B	4-MAR-21	AZ	HSE	
A	4-FEB-21	AZ	HSE	

doc.type | abbr. | taken from/replaces/drwg no.location

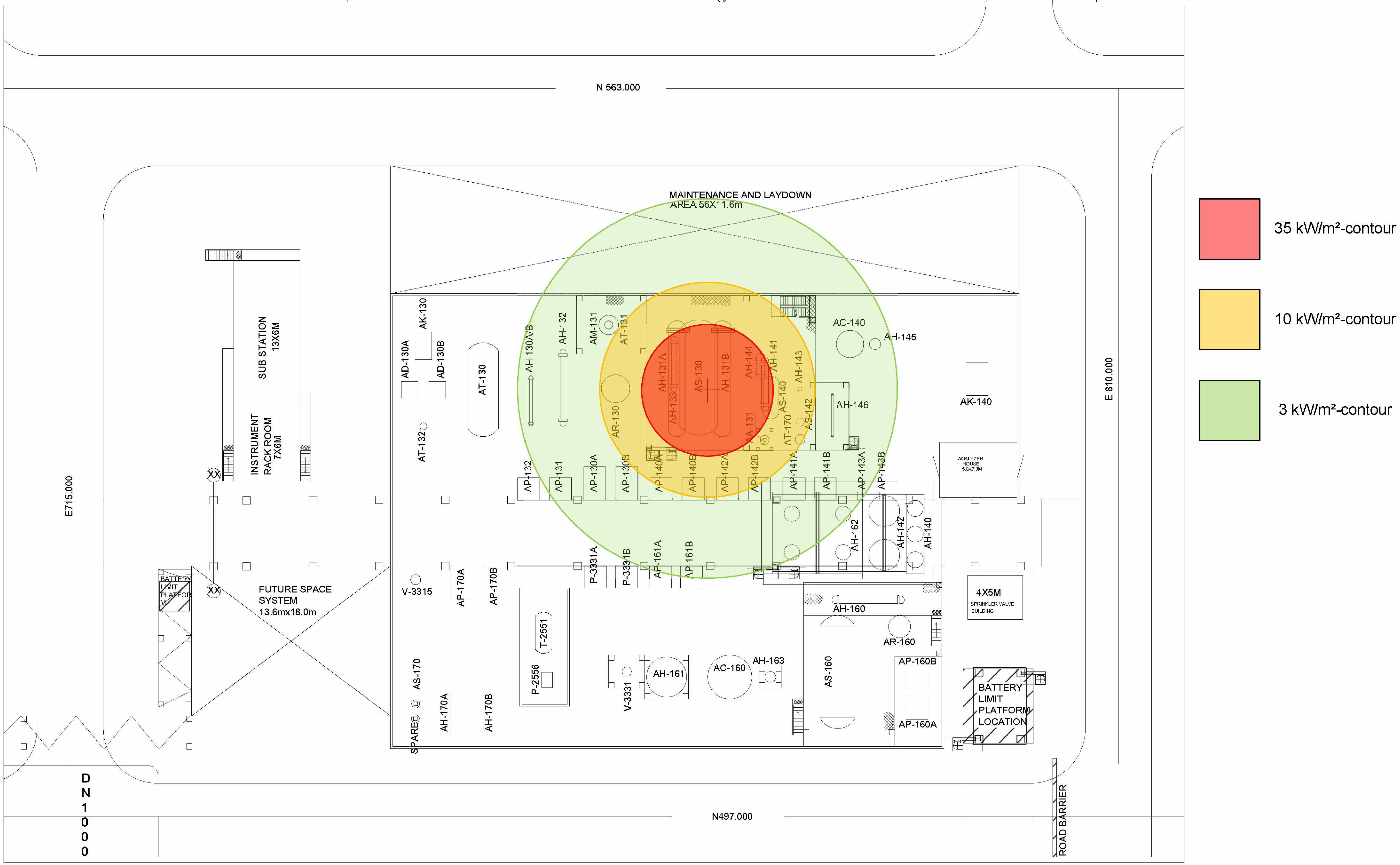
Shin-Etsu FLUOR

doc.no. A8NX-HTDC-653-PLN-001-00001 APPENDIX A

sh. 1 of 5

88-08 Contractor doc.no. : A8XN-HTDC-653-PLN-001-00001 57.16.42 E

AMENU Tabletmenu: AREV AutoCAD-rev.



052		100			A3	
fact.no.	fact.dpt	processgr./-unit	itemcode/tag no.	project no.	size	higher reference doc. no. / part no

title: Heat Radiation 2E Fire
AS-130 HTDC Reactor Reflux Drum

fact./fact.dept: Shin-Etsu VCM bv
project: HTDC Project

rev	date	by	dept.	ckd
B	4-MAR-21	AZ	HSE	
A	4-FEB-21	AZ	HSE	

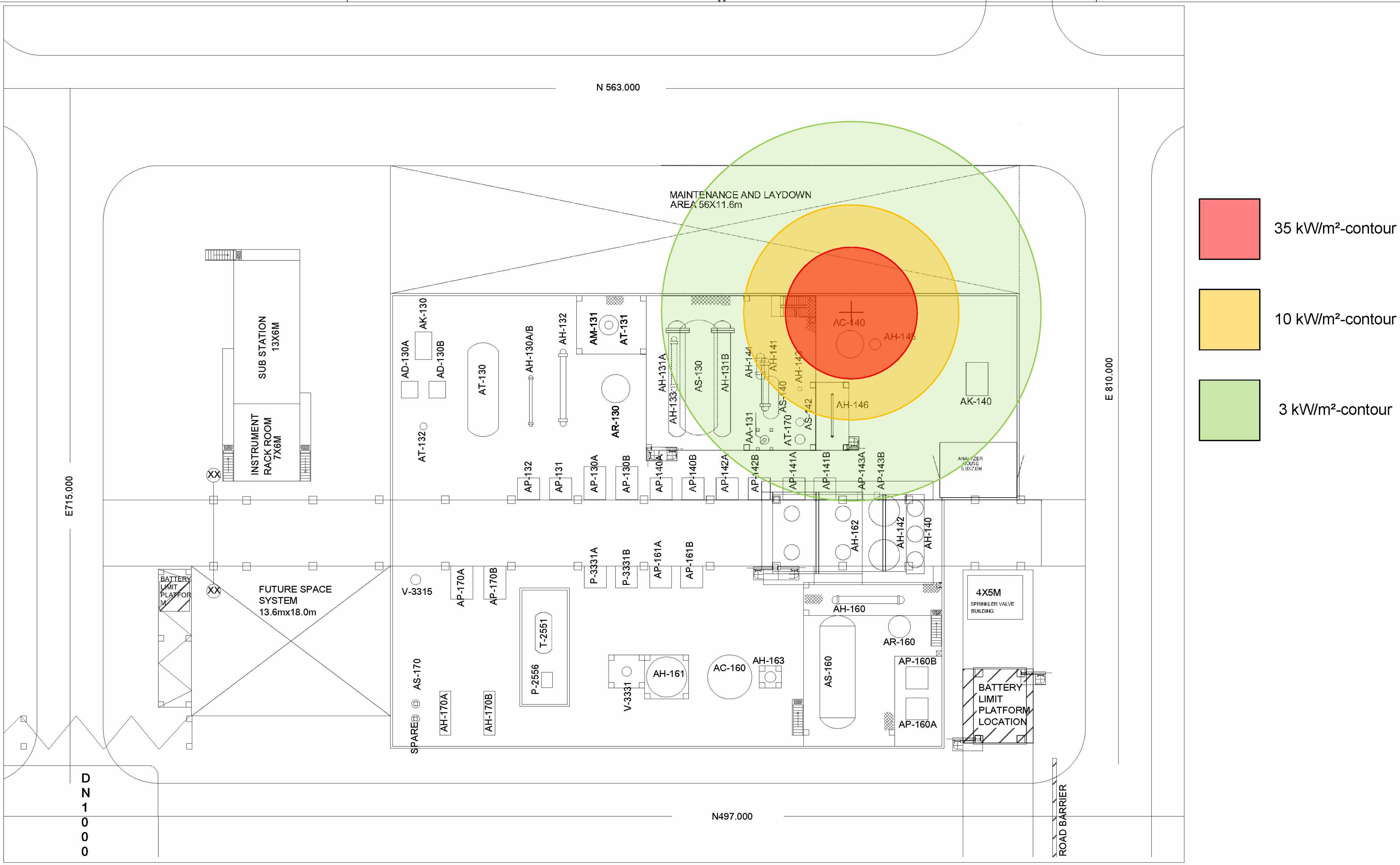
doc.type | abbr. | taken from/replaces/drwg no.location

doc.no. A8NX-HTDC-653-PLN-001-00001
APPENDIX A

sh. 2 of 5

88-08 Contractor doc.no. : A8XN-HTDC-653-PLN-001-00001 57.16.42 E

AutoCAD-rev. AREV Tabletmenu: AMENU



052		100			A3	
fact.no.	fact.dpt	processgr./-unit	itemcode/tag no.	project no.	size	higher reference doc. no. / part no

title: Heat Radiation 2E Fire
AC-140 HTDC Purification Column

fact./fact.dept: Shin-Etsu VCM bv
project: HTDC Project

rev	date	by	dept.	ckd
B	4-MAR-21	AZ	HSE	
A	4-FEB-21	AZ	HSE	

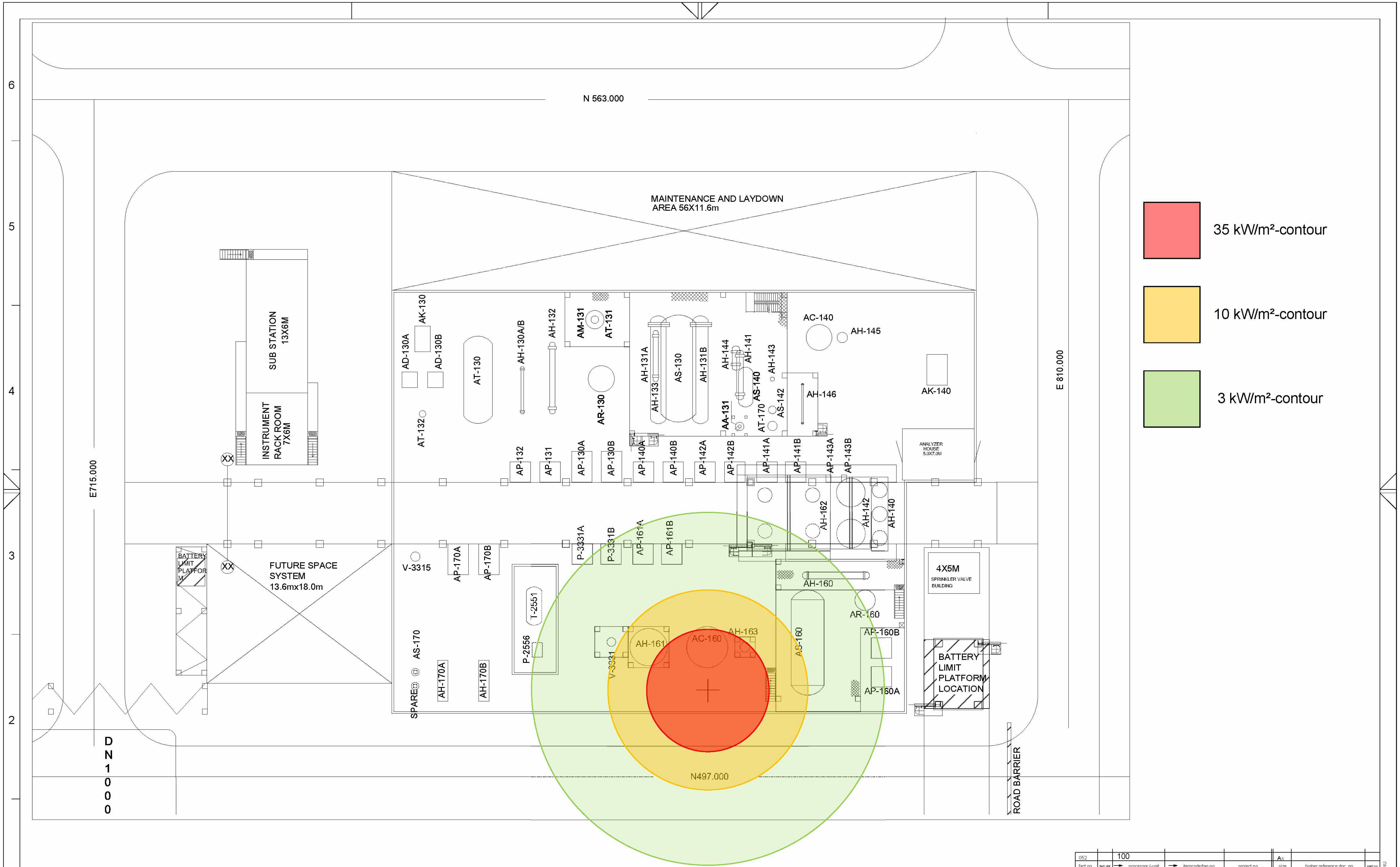
doc.type | abbr. | taken from/replaces/drwg no.location

Shin-Etsu FLUOR®

doc.no. A8NX-HTDC-653-PLN-001-00001 APPENDIX A
sh. 3 of 5

88-08 Contractor doc.no.: A8XN-HTDC-653-PLN-001-00001 57.16.42 E

AMENU Tabletmenu: AREV AutoCAD-rev.



052		100			A3	
fact.no.	fact.dpt	processgr./-unit	itemcode/tag no.	project no.	size	higher reference doc. no. / part no

title: Heat Radiation 2E Fire
AC-160 Recycle EDC Column

fact./fact.dept: Shin-Etsu VCM bv
project: HTDC Project

rev	date	by	dept.	ckd
B	4-MAR-21	AZ	HSE	
A	4-FEB-21	AZ	HSE	

doc.type | abbr. | taken from/replaces/drwg no.location

Shin-Etsu FLUOR®

doc.no. A8NX-HTDC-653-PLN-001-00001 APPENDIX A

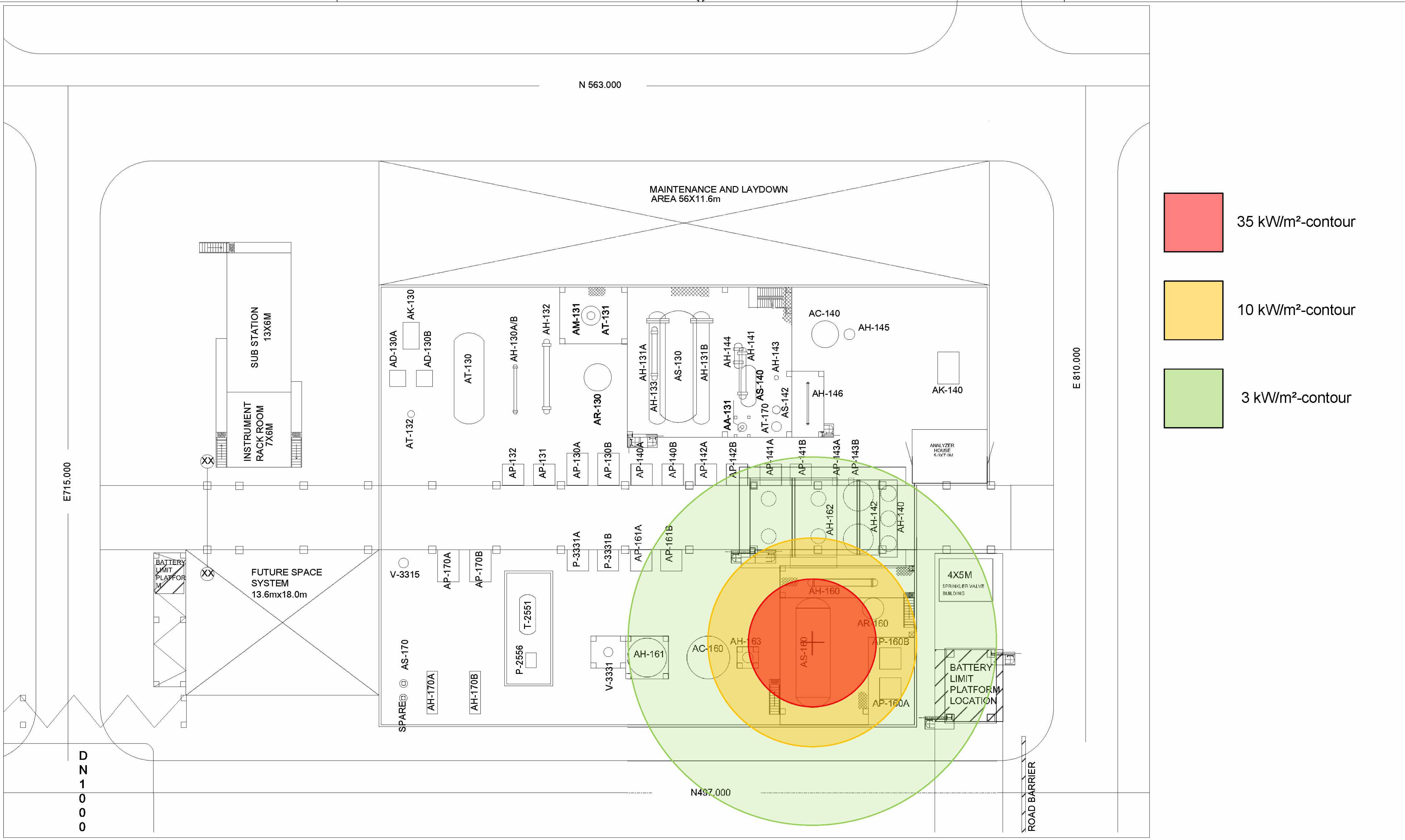
sh. 4 of 5

88-08

Contractor doc.no. : A8XN-HTDC-653-PLN-001-00001

57.16.42 E

AutoCAD-rev. AREV Tabletmenu: AMENU



052		100			A3
fact.no.	fact.dpt	processgr./-unit	itemcode/tag no.	project no.	size

higher reference doc. no. | part no

title: Heat Radiation 2E Fire
AS-160 Recycle EDC Reflux Accu

fact./fact.dept: Shin-Etsu VCM bv
project: HTDC Project

rev	date	by	dept.	ckd
B	4-MAR-21	AZ	HSE	
A	4-FEB-21	AZ	HSE	

doc.type | abbr. | taken from/replaces/drwg no.location

doc.no. A8NX-HTDC-653-PLN-001-00001 APPENDIX A

sh. 5 of 5

AutoCAD-rev. AREV Tabletmenu: AMENU

88-08 Contractor doc.no. : A8XN-HTDC-653-PLN-001-00001 57.16.42 E