TRANSFORMER PROTECTOR

The only proven solution against transformer explosions.

Adaptation on New Transformers

TRANSFORMER PROTECTOR

SERGI

Transformer, On Load Tap Changer, Oil Cable Boxes Explosion and Fire Prevention, from 0.1 MVA

Transformers, On Load Tap Changer and Oil Cable Box Explosion and Fire Prevention

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The only proven solution against transformer explosions.

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[2]	AtTPra02b01e	"Transformer Relief Valves efficiency calculations by comparison to the TRANSFORMER PROTECTOR during short-circuits",
[3]	AtTPra03b03e	"Transformer Explosion and Fire Incidents. Guideline for Damage Cost Evaluation. Transformer Protector Financial Benefit",
[4]	AtTPrdab	"Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations", NFPA 850, 2010 edition
[5]	AtTPrdac	"Recommended Practice for Fire Protection for Hydroelectric Generating Plants", NFPA 851, 2010 edition

No.	Reference	Additional Documents
[6]	AtTPrtfa	Attestation from CEPEL Laboratory
[7]	FtTPgd	Brochure
[8]	FtTPpa	Adaptation on New Transformers
[9]	FtTPpb	Adaptation on Existing Transformers
[10]	FtTPpc	On-Site Installation, Commissioning, and Testing
[11]	FtTPpd	Operation, Maintenance, and Periodical Test
[12]	FtTPdb	TP Description to be used for Customer Technical Specification

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SUMMARY

This document is intended for the Project Manager, Electrical Manager, and Subcontractors. It describes all of the steps to prepare for the installation of the TRANSFORMER PROTECTOR (TP) on new transformers (under manufacturing).

Chapter 1 explains the fundamentals of the TP, as well as its principles, description of the available types, and recommended applications.

Chapter 2 shows the Depressurization Set Standard Arrangement and other alternatives from the Standard Arrangement.

Chapter 3 shows the Oil-Gas Separation Tank Standard Arrangement and other alternatives from
the Standard Arrangement.

Chapter 4 presents the scope of supply for the adaptation of the TP to the new transformers.

Chapter 5 explains the Depressurization Set (DS) size for the different transformer power ratings.

Chapter 6 describes the Transformer Interfaces Analysis.

Chapter 7 gives a description of the TP Components.

Chapter 8 explains the electrical connections involved with the TP.

Chapter 9 explains the piping requirements for the installation of the TP.

Chapter 10 explains options that may be purchased by the client.

Chapter 11 explains items that are not in the TP Scope of Supply.

Chapter 12 provides a table of Abbreviations.

Chapter 13 provides a Glossary of TP Components.

1 INTRODUCTION

1.1 TRANSFORMER PROTECTOR PRESENTATION

The TRANSFORMER PROTECTOR (TP) is a transformer explosion and fire prevention system suitable for any type of oil-immersed transformer, On Load Tap Changer (OLTC), Oil Cable Box (OCB), and Oil Bushing Cable Box (OBCB). During a short circuit, the TP is activated within milliseconds by the first dynamic pressure peak of the shock wave, avoiding transformer explosion before static pressure increases.

1.1.1 RECOMMENDED APPLICATIONS

Application examples for the TP model are listed below with reference to Figures 1, 2, 3, and 4. The TP, TPA, TPB, and TPAB are used on transformers located indoors and outdoors. When activated the explosive oil and gases are routed to the OGST which are then separated. The explosive gases are routed to a remote area where they are evacuated without causing possible damage to the plant equipment.

Both models can be utilized on transformers such as in the following applications:

- Power Plants, (especially Hydro Power Plants, when the transformers are located underground in galleries below dams);
- Industrial plants, (when transformers are located near factories or offices);
- Outdoor substations located inside cities or near buildings or houses;
- Outdoor substations that are not equipped with Oil Collecting Ducts and Remote Oil Storage Pits;
- Indoor and outdoor industrial plants with high explosion risks, such as oil refineries and offshore plants;
- Railway network power supply stations;
- Underground power distribution networks;
- Sensitive environmental areas.

1.1.2 EFFICIENCY

The research results explained:

- The TP Rupture Disk is fully opened in a time span varying from 0.5 to a few milliseconds, depending on the amount of energy transferred to the oil by the electrical fault;
- In addition, the Rupture Disk responds to the severity of the fault. For a greater pressure gradient the full opening time is shorter than for a smaller pressure gradient;
- The TP DS is able to bring the main tank , OLTC, OCB, and OBCB pressure back to normal in a few milliseconds;
- To achieve the above results, the DS operational diameter varies from DN 100 to DN 300, (4 to 12-inch), depending on the transformer size and power rating.

1.1.3 AVAILABLE MAIN TP CONFIGURATIONS

- **TP type,** Figure 1, is suitable for transformers from 0.1 MVA up to 1,000 MVA and above, located either indoors or outdoors. In this type, the transformer Depressurization Set (items 6-9) will allow the depressurization in case of an internal fault. The depressurized oil and gas mixture is routed to an Oil-Gas Separation Tank (item 22). The gases are expelled through the Explosive Gas Evacuation Pipe (item 23), outside the building or to a remote area where gases can burn safely. An Air Isolation Shutter (item 24) is installed at the end of the Explosive Gas Evacuation Pipe (item 23) to avoid air from entering into the Oil-Gas Separation Tank (item 22) or the transformer tank.

- **TPA type,** Figure 2, is suitable for transformers from 0.1 MVA up to 1,000 MVA and above, located either indoors or outdoors. In this type, the transformer and OLTC Depressurization Sets (items 6-9 and 12-13) will allow the depressurization in case of an internal fault. The depressurized oil and gas mixture is routed to an Oil-Gas Separation Tank (item 22). The gases are expelled through the Explosive Gas Evacuation Pipe (item 23), outside the building or to a remote area where gases can burn safely. An Air Isolation Shutter (item 24) is installed at the end of the Explosive Gas Evacuation Pipe (item 23) to avoid air from entering into the Oil-Gas Separation Tank (item 22) or the transformer tank.

- **TPB type,** Figure 3, is suitable for transformers from 0.1 MVA up to 1,000 MVA and above, located either indoors or outdoors. In this type, the transformer and OCB Depressurization Sets (items 6-9 and 26-28) will allow the depressurization in case of an internal fault. The depressurized oil and gas mixture is routed to an Oil-Gas Separation Tank (item 22). The gases are expelled through the Explosive Gas Evacuation Pipe (item 23), outside the building or to a remote area where gases can burn safely. An Air Isolation Shutter (item 24) is installed at the end of the Explosive Gas Evacuation Pipe (item 23) to avoid air from entering into the Oil-Gas Separation Tank (item 22) or the transformer tank.

- **TPAB type,** Figure 4, is suitable for transformers from 0.1 MVA up to 1,000 MVA and above, located either indoors or outdoors. In this type, the transformer, OLTC, and OCB Depressurization Sets (items 6-9, 12-13 and 26-28) will allow the depressurization in case of an internal fault. The depressurized oil and gas mixture is routed to an Oil-Gas Separation Tank (item 22). The gases are expelled through the Explosive Gas Evacuation Pipe (item 23), outside the building or to a remote area where gases can burn safely. An Air Isolation Shutter (item 24) is installed at the end of the Explosive Gas Evacuation Pipe (item 23) to avoid air from entering into the Oil-Gas Separation Tank (item 22) or the transformer tank.

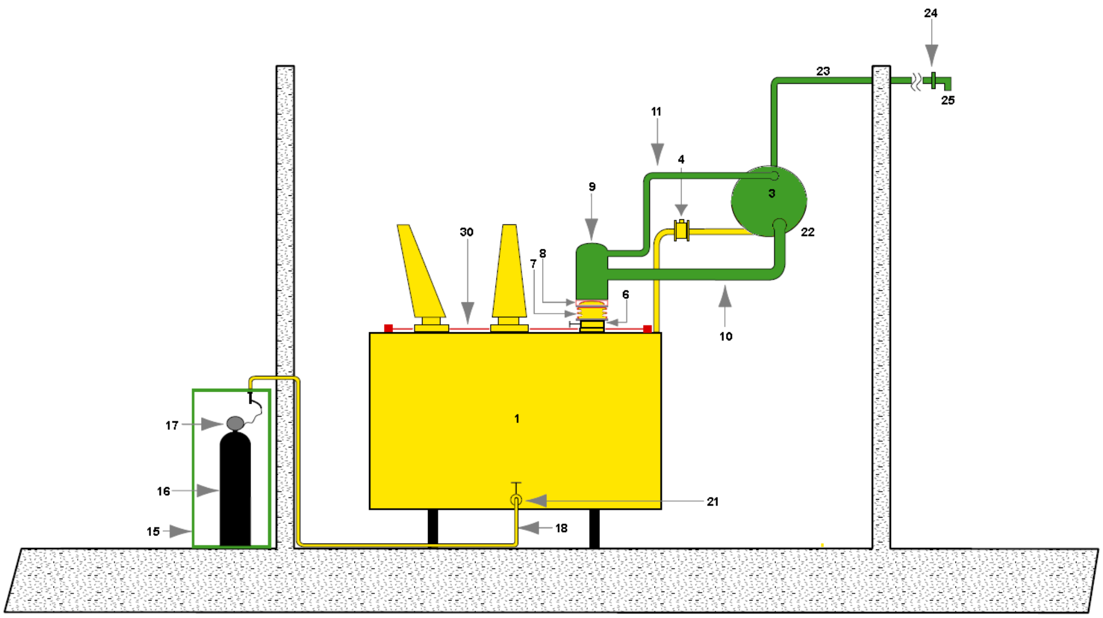


Figure 1: TRANSFORMER PROTECTOR, TP type

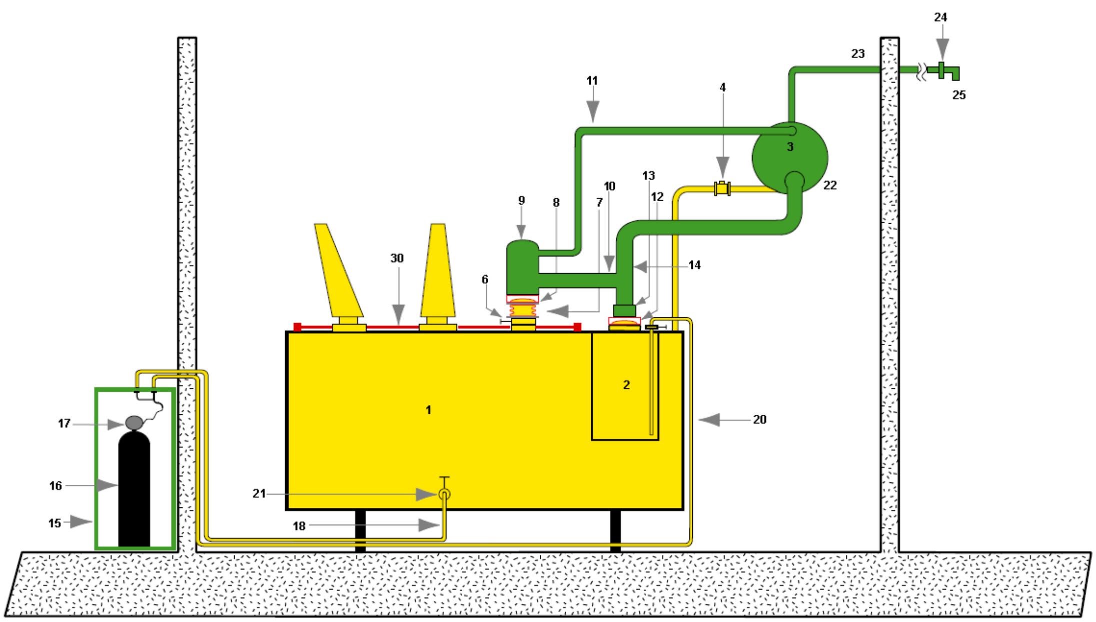


Figure 2: TRANSFORMER PROTECTOR, TPA type

NO.	DESCRIPTION	ABREV.	NO.	DESCRIPTION	ABREV.
1	Transformer	-	14	OLTC Oil Drain Pipe	OLTC ODP
2	On Load Tap Changer	OLTC	15	TP Cabinet	-
3	Conservator Tank	-	16	Inert Gas Cylinder	-
4	Buchholz	-	17	Electrical Actuator	EA
6	Isolation Valve	IV	18	Inert Gas Injection Pipe to Transformer	IGIP
7	Shock Absorber	SA	20	Inert Gas Injection Pipe to OLTC	OLTC IGIP
8	Rupture Disk	RD	21	Inert Gas Injection Valve(s) - Transformer	IGIV
9	Decompression Chamber	DC	22	Sliced Oil-Gas Separation Tank	SOGST
10	Oil Drain Pipe	ODP	23	Explosive Gas Evacuation Pipe	EGEP
11	Gas Evacuation Pipe	GEP	24	Air Isolation Shutter	AIS
12	OLTC Rupture Disk	OLTC RD	25	Explosive Gases evacuated to safe area	-
13	OLTC Decompression Chamber	OLTC DC	30	Linear Heat Detector	LHD

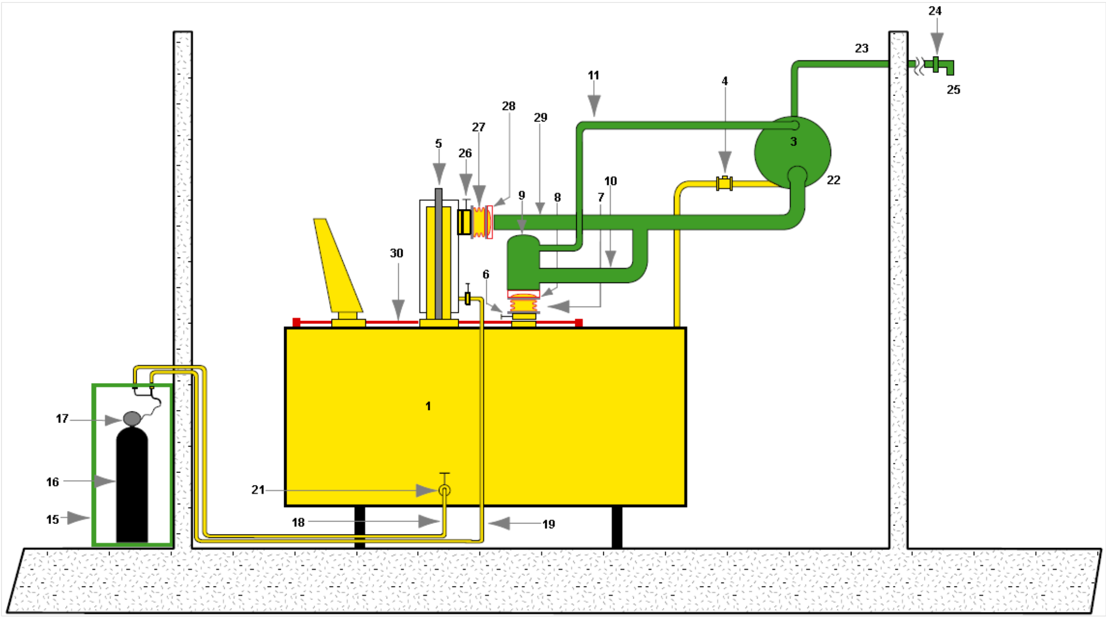


Figure 3: TRANSFORMER PROTECTOR, TPB type

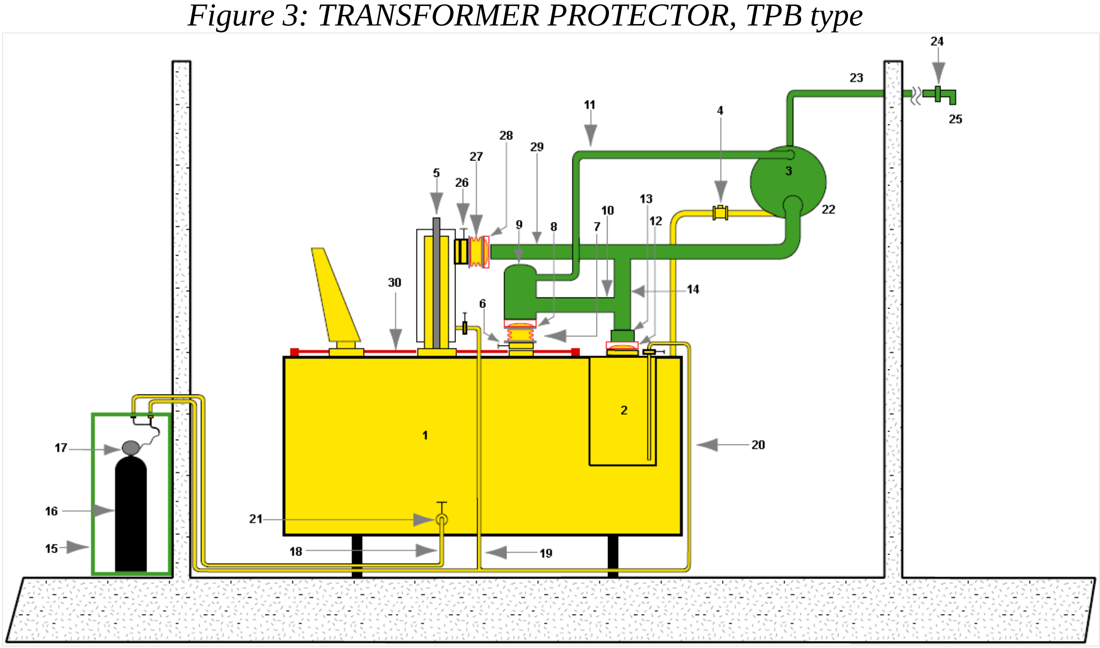


Figure 4: TRANSFORMER PROTECTOR, TPAB type

NO.	DESCRIPTION	ABREV.	NO.	DESCRIPTION	ABREV.
1	Transformer	-	16	Inert Gas Cylinder	-
2	On Load Tap Changer	OLTC	17	Electrical Actuator	EA
3	Conservator Tank	-	18	Inert Gas Injection Pipe to Transformer	IGIP
4	Buchholz	-	19	Inert Gas Injection Pipe to OCB	OCB IGIP
5	Oil Cable Box	OCB	20	Inert Gas Injection Pipe to OLTC	OLTC IGIP
6	Isolation Valve	IV	21	Inert Gas Injection Valve(s) - Transformer	IGIV
7	Shock Absorber	SA	22	Sliced Oil-Gas Separation Tank	SOGST
8	Rupture Disk	RD	23	Explosive Gas Evacuation Pipe	EGEP
9	Decompression Chamber	DC	24	Air Isolation Shutter	AIS
10	Oil Drain Pipe	ODP	25	Explosive Gases evacuated to safe area	-
11	Gas Evacuation Pipe	GEP	26	Oil Cable Box Isolation Valve	OCB IV
12	OLTC Rupture Disk	OLTC RD	27	Oil Cable Box Shock Absorber	OCB SA
13	OLTC Decompression Chamber	OLTC DC	28	Oil Cable Box Rupture Disk	OCB RD
14	OLTC Oil Drain Pipe	OLTC ODP	29	Oil Cable Box Oil Drain Pipe	OCB ODP
15	TP Cabinet	-	30	Linear Heat Detector	LHD

1.1.4 ARRANGEMENT PRINCIPLES

The TP is made up of several sets, each performing a different function, with reference to Figures 1, 2, 3, and 4.

1.1.4.1 Depressurization Set (DS)

Due to its mechanical arrangement, the TP is able to depressurize the transformer without the need of an external trigger. The DS will function even when the voltage supply becomes unavailable. The DS includes a Rupture Disk (items 8, 12 and 28) which relieves the overpressure condition within a few milliseconds and a Decompression Chamber (items 9 and 13) to allow high-speed depressurization.

The transformer, OLTC, and OCB DS (items 6-9, 12-13, and 26-28) prevent the transformer, OLTC and OCB from exploding in the case of an internal electrical fault and overpressure conditions.

1.1.4.2 Oil-Gas Separation Tank (OGST)

The OGST (item 22) collects and separates the depressurized oil and the explosive flammable gas mixture. The OGST cannot be shared with other nearby TPs.

1.1.4.3 Explosive Gas Evacuation Set (EGES)

The EGES (items 23-25) channels all gases to a remote area out and away from the transformer and surrounding equipment.

1.1.4.4 Inert Gas Injection Set (IGIS)

The IGIS creates a safe environment inside the transformer, OLTC (if applicable), and OCB (if applicable) after the depressurization process by injecting inert gas. The IGIS consist of one TP Cabinet, which has a manifold kit with two connections to un-proportionally distribute the inert gas into the transformer, OLTC, and OCB respectively, a Flexible Hose to connect the manifold with the inert gas cylinder, one Pressure Reducer to smoothly inject the inert gas, one Inert Gas Cylinder with Manometer, and one Heater with a Thermostat.

The inert gas flow will route the explosive gases to a remote area, prevents air (oxygen) from coming into contact with the self-flammable gases, and further cools down the transformer.

The inert gas equalizes the oil temperature in contact with:

- The locally warmed gases, between 1000 and 2000°C (1832 and 3632 °F), that are created by the electrical arc.
- The overheated metallic components, up to 680°C (1256 °F) for aluminum parts and 1080°C (1976 °F) for copper windings.

The inert gas injection process occurs approximately 45 minutes. After the inert gas injection is completed, the maintenance team can start working on the transformer.

a) Logic of Operation Modes

Prevention Mode

- The integrated Rupture Disk Burst Indicator signal confirms the overpressure state and the beginning of the depressurization process; and
- One of any of the electrical protection signals to confirm an electrical fault in the protected transformer.

Extinction Mode

- The Linear Heat Detector (item 30) signal confirms a fire has occurred around the transformer; and
- One of any of the electrical protection signals to confirm an electrical fault in the transformer.

Control Box in Automatic Mode

With the required signals present, the Control Box sends an output voltage to the IGIS. The Automatic Trigger for Inert Gas Cylinder will then allow the automatic injection of inert gas smoothly into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).

Control Box in Manual Mode

Manual Inert Gas Injection can be performed by putting the Control Box into the manual mode and pressing the “Manual Activation” push button allowing the Automatic Trigger for Inert Gas Cylinder to activate the injection of inert gas smoothly into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).

b) Inert Gas Injection

Automatic Trigger for Inert Gas Cylinder (Standard Scope of Supply)

- Automatic Inert Gas Injection (standard configuration of the TP) is activated when the Control Box receives two simultaneous signals (Rupture Disk + Electrical Protection or Linear Heat Detector + Electrical Protection), therefore sending the inert gas activation signal to the Automatic Trigger for the Inert Gas Cylinder allowing the automatic injection of inert gas into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).

Manual Trigger for Inert Gas Cylinder (Option)

- This option is ordered by clients who want to inject inert gas directly from the TP Cabinet. Manual injection can be done by removing the safety pin and pressing down the lever of the Manual Trigger for Inert Gas Cylinder. The Manual Trigger for Inert Gas Cylinder will then allow the injection of inert gas into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).

Automatic/Manual Trigger for Inert Gas Cylinder (Option)

- Automatic Inert Gas Injection is activated when the Control Box receives two simultaneous signals (Rupture Disk + Electrical Protection or Linear Heat Detector + Electrical Protection); therefore sending the inert gas activation signal to the Automatic Trigger for the Inert Gas Cylinder allowing the automatic injection of inert gas into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).
- The second injection device option available is the Manual Inert Gas Injection, which will allow the client to inject inert gas directly from the TP Cabinet. This process is done by removing the safety pin and pressing down the lever of the Manual Trigger for Inert Gas Cylinder.

1.2 WARNING

1.2.1 PRV PRESSURE SETTING REQUIREMENT

SERGI France requests at least one transformer tank Pressure Relief Valve (PRV) for each transformer and External OLTC to be protected. If the transformer tank is not equipped with this device, a quote can be requested and the PRV can be supplied with the TP. The PRV calibration setting pressure must be sent to SERGI France.

1.2.2 ELECTRICAL PROTECTION

The TP activation operates in two different modes which are the following:

- Prevention Mode
- Extinction Mode

Both modes require two signals in which one of the signals will come from the TP system (Rupture Disk or Linear Heat Detector) and another will be one of Electrical Protection Signals (Buchholz, Differential, Earth Fault, or Over-Current) supplied by the client from the transformer.

The Control Box will confirm that a transformer internal fault has occurred with these electrical protection signals. Please refer to Section 8.2 for more details on the functionality of the Electrical Protection signals with the TP system.

1.2.3 STORAGE

When storing the equipment it should be protected from dust, water, humidity, shocks, vibrations, excessive heat, cold, excessive weight, fire, vermin, mishandling, and theft. If this is not done, SERGI France withdraws its guarantee regarding the sold material condition.

2 DEPRESSURIZATION SET ARRANGEMENT

2.1 VERTICAL DS STANDARD ARRANGEMENT

2.1.1 GENERAL VIEW

The TP Standard Arrangement for the transformer Depressurization Set (DS) is composed of a Vertical Depressurization Set (VDS), which is positioned on the transformer cover.

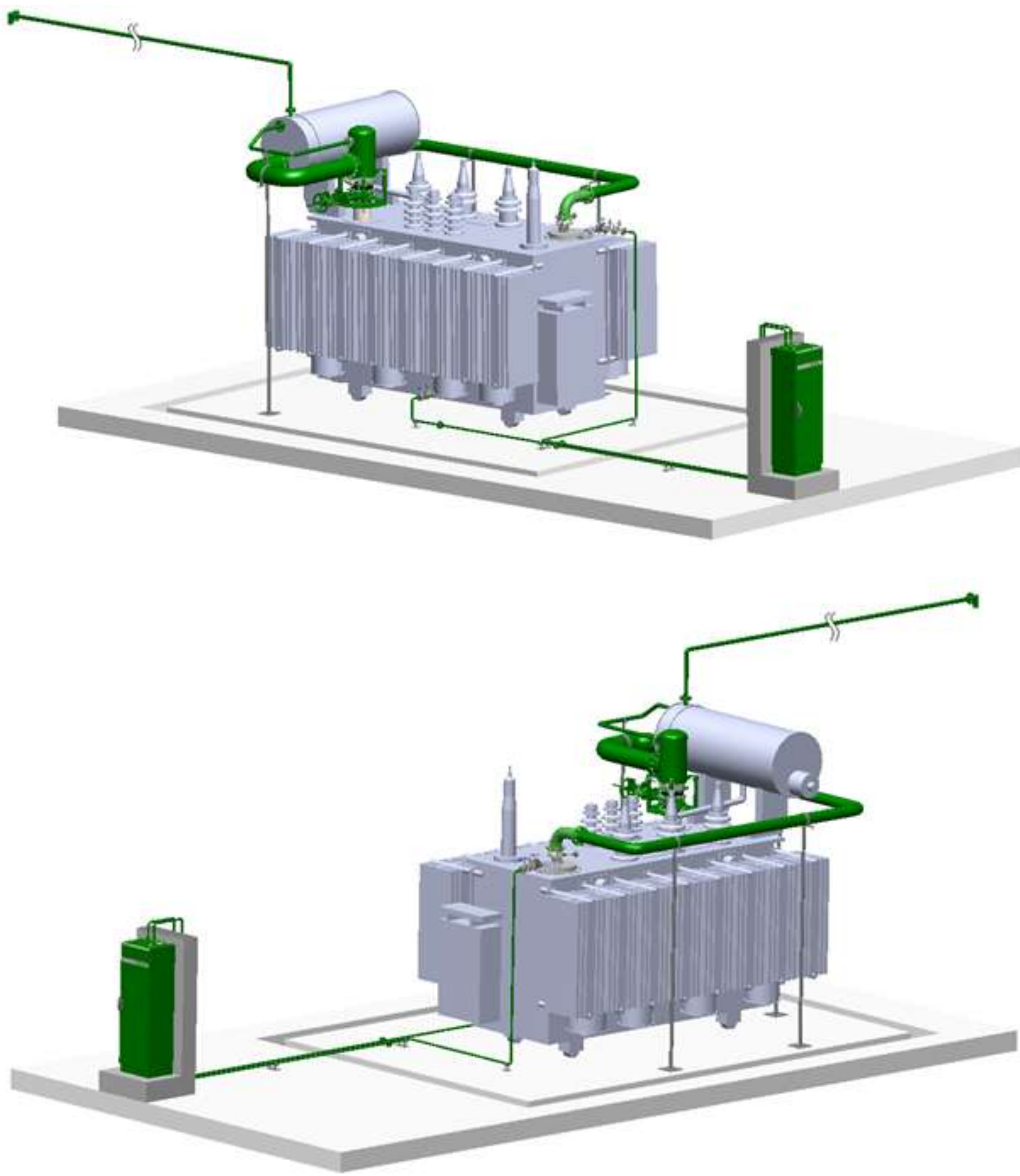


Figure 5: Standard Arrangement of the TP (VDS)

2.1.1.1 Vertical Depressurization Set

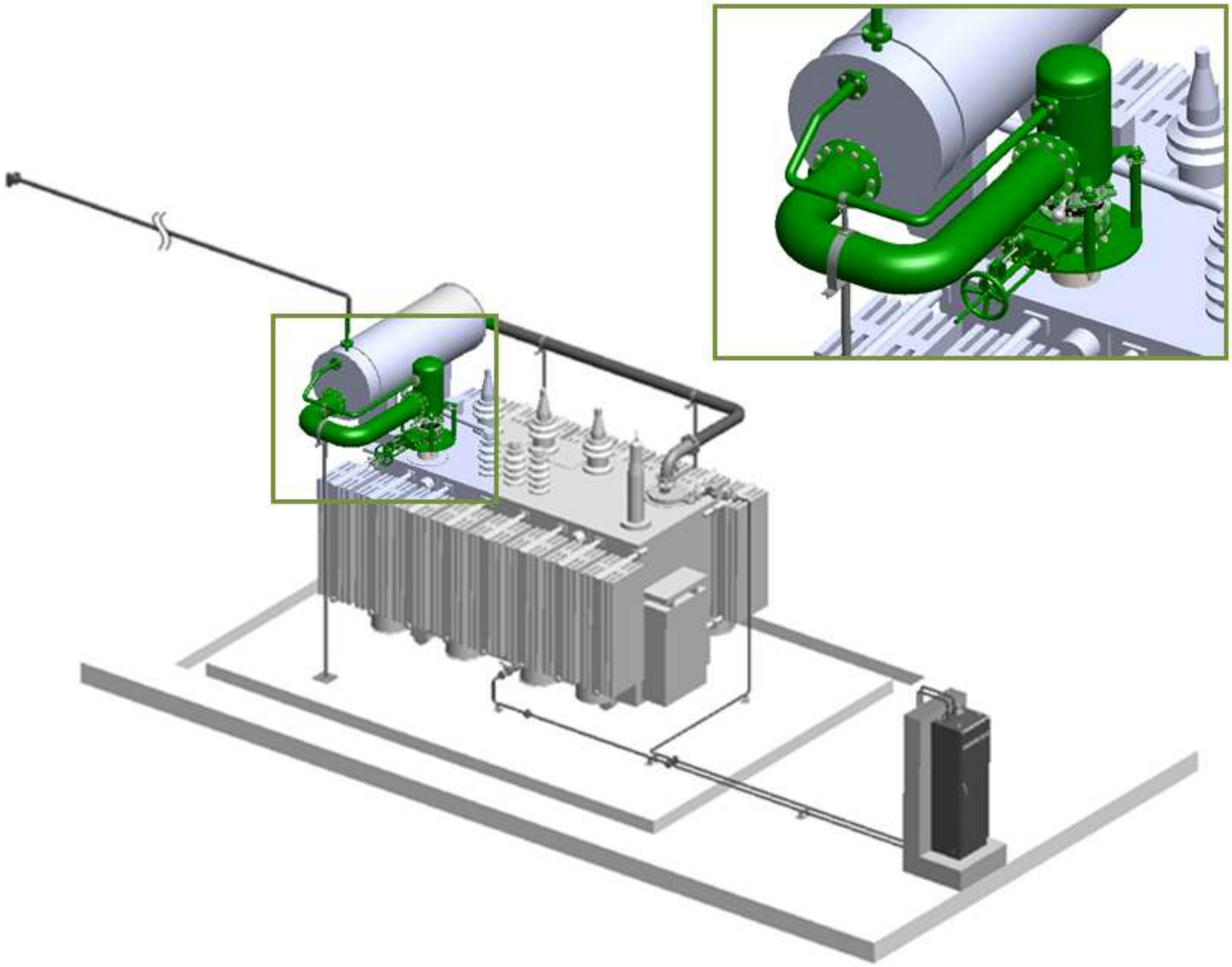


Figure 6: Vertical Depressurization Set, Isometric View

The VDS is mounted on a Vertical Adaptation Piece installed on the transformer cover. The VDS is installed at the most suitable location based on the space available without interfering with the transformer's subcomponents and away from bushings electrical clearance.

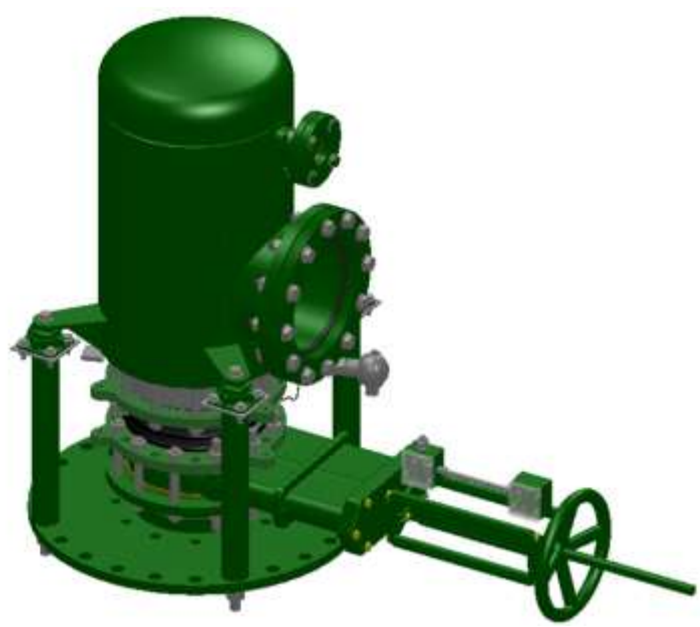


Figure 7: Vertical Depressurization Set

2.2 ALTERNATE ARRANGEMENT

There exist two alternatives to substitute the VDS when constraints are found at the time of confirming the best TP configuration. The first alternative is a 45° Depressurization Set (45°DS); the second alternative is a Horizontal Depressurization Set (HDS).

2.2.1 45° DEPRESSURIZATION SET GENERAL VIEW

The first TP alternative arrangement for the transformer DS is composed of a 45°DS, which is positioned on the transformer cover.

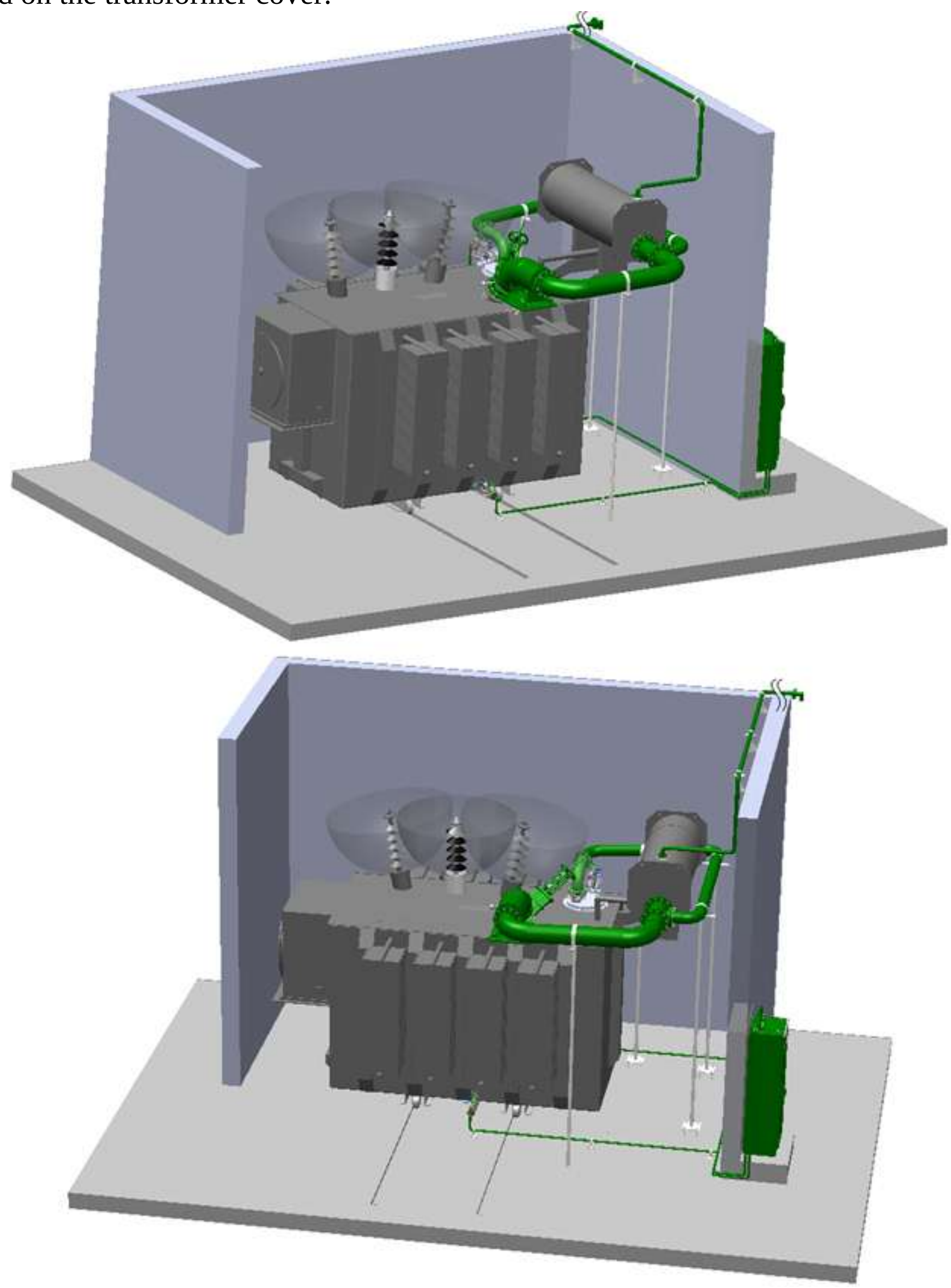


Figure 8: 45° Depressurization Set, Isometric View

2.2.1.1 45° Depressurization Set

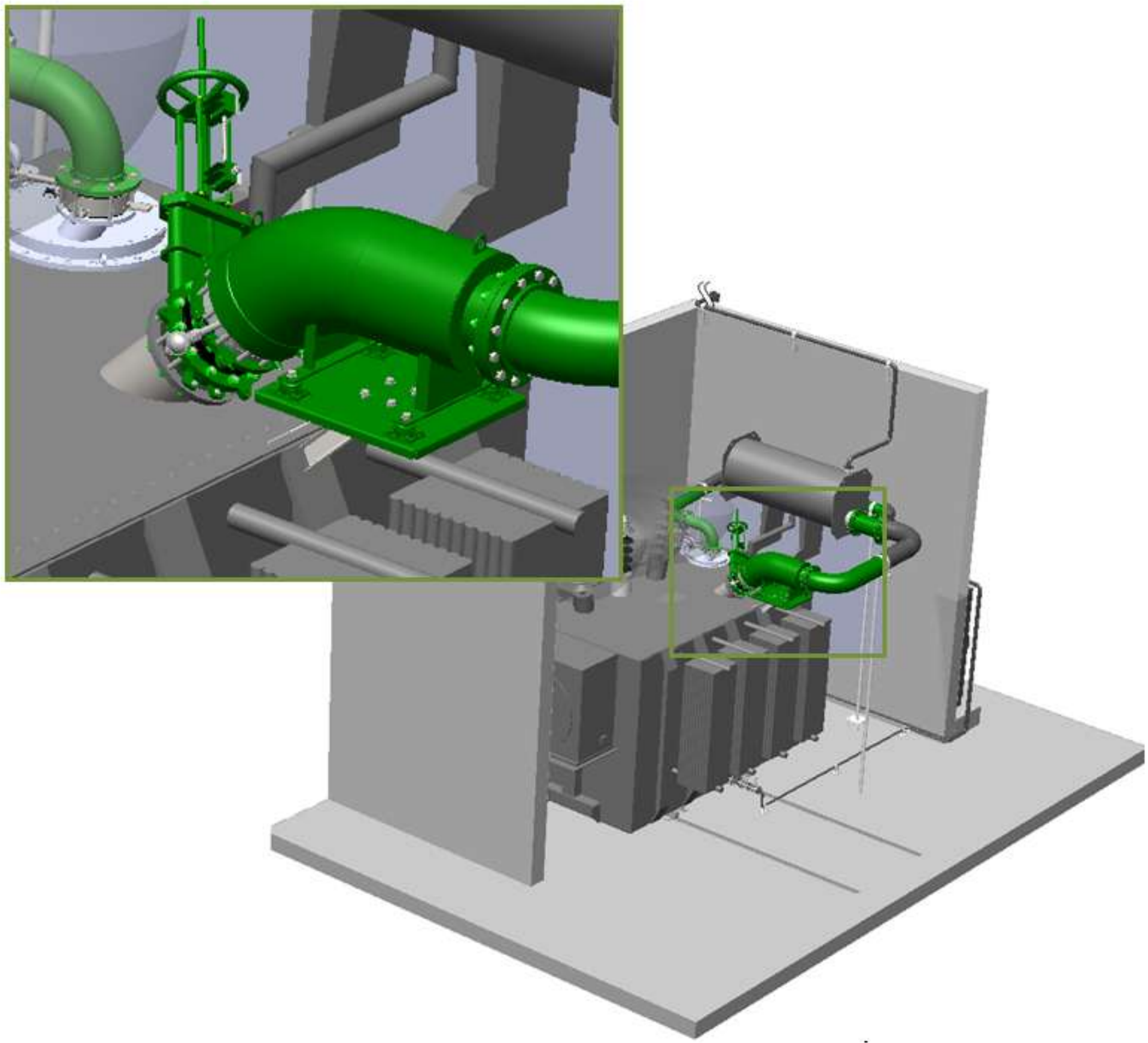


Figure 9: 45° Depressurization Set, Isometric View

The 45°DS is mounted on a 45° Adaptation Piece installed on the transformer cover. The 45°DS should be installed at the most suitable location based on the space available without interfering with the transformer's subcomponents and away from bushings electrical clearance.

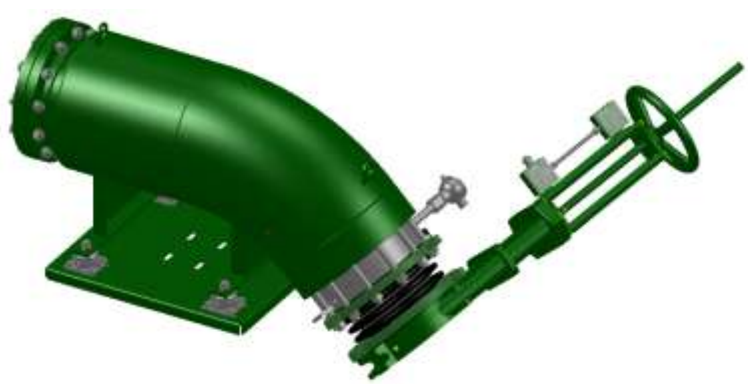


Figure 10: 45° Depressurization Set

2.2.2 HORIZONTAL DEPRESSURIZATION SET GENERAL VIEW

The second TP alternative arrangement for the transformer DS is composed of a HDS which is positioned on the transformer side wall.

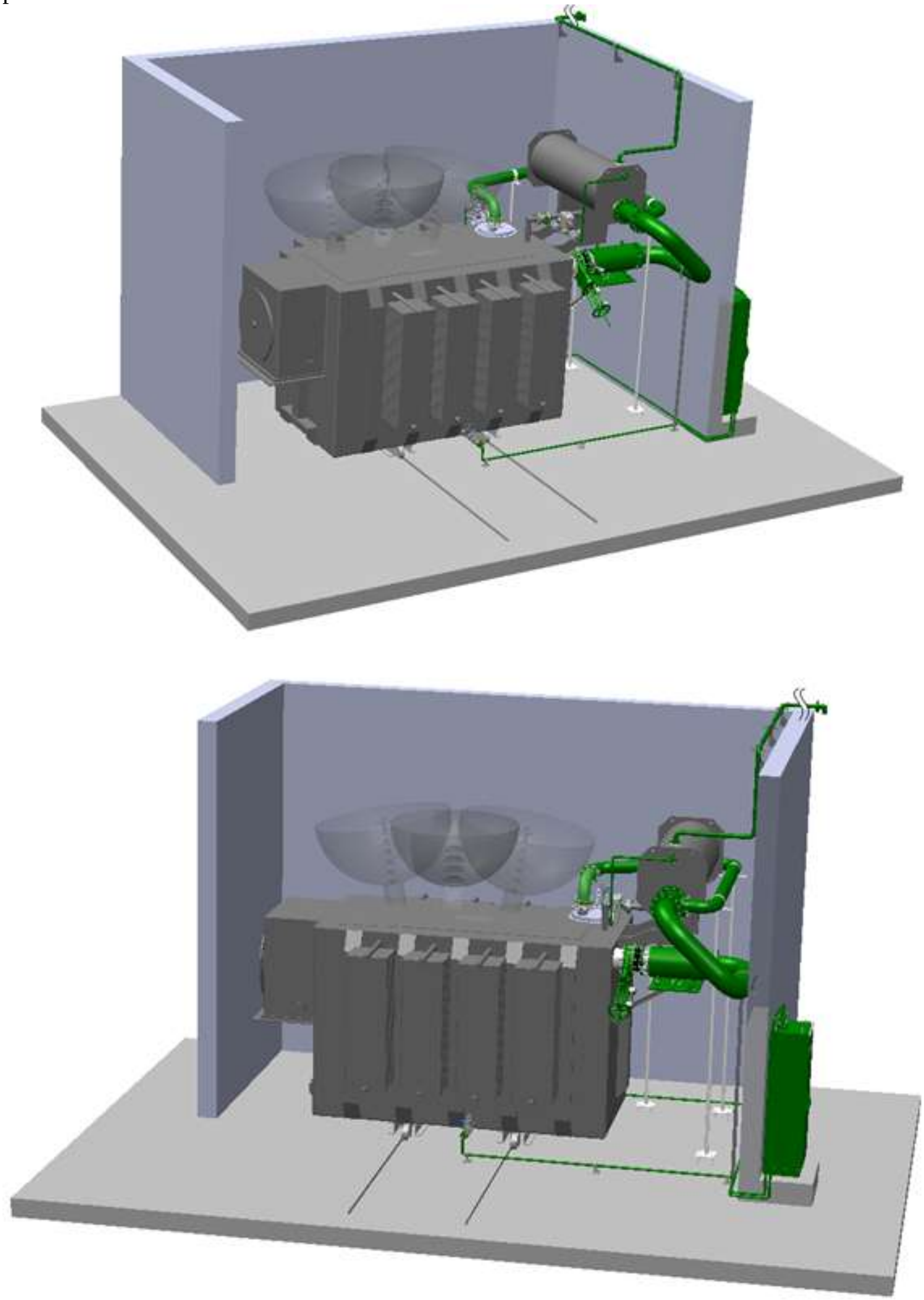


Figure 11: Horizontal Depressurization Set, Isometric View

2.2.2.1 Horizontal Depressurization Set

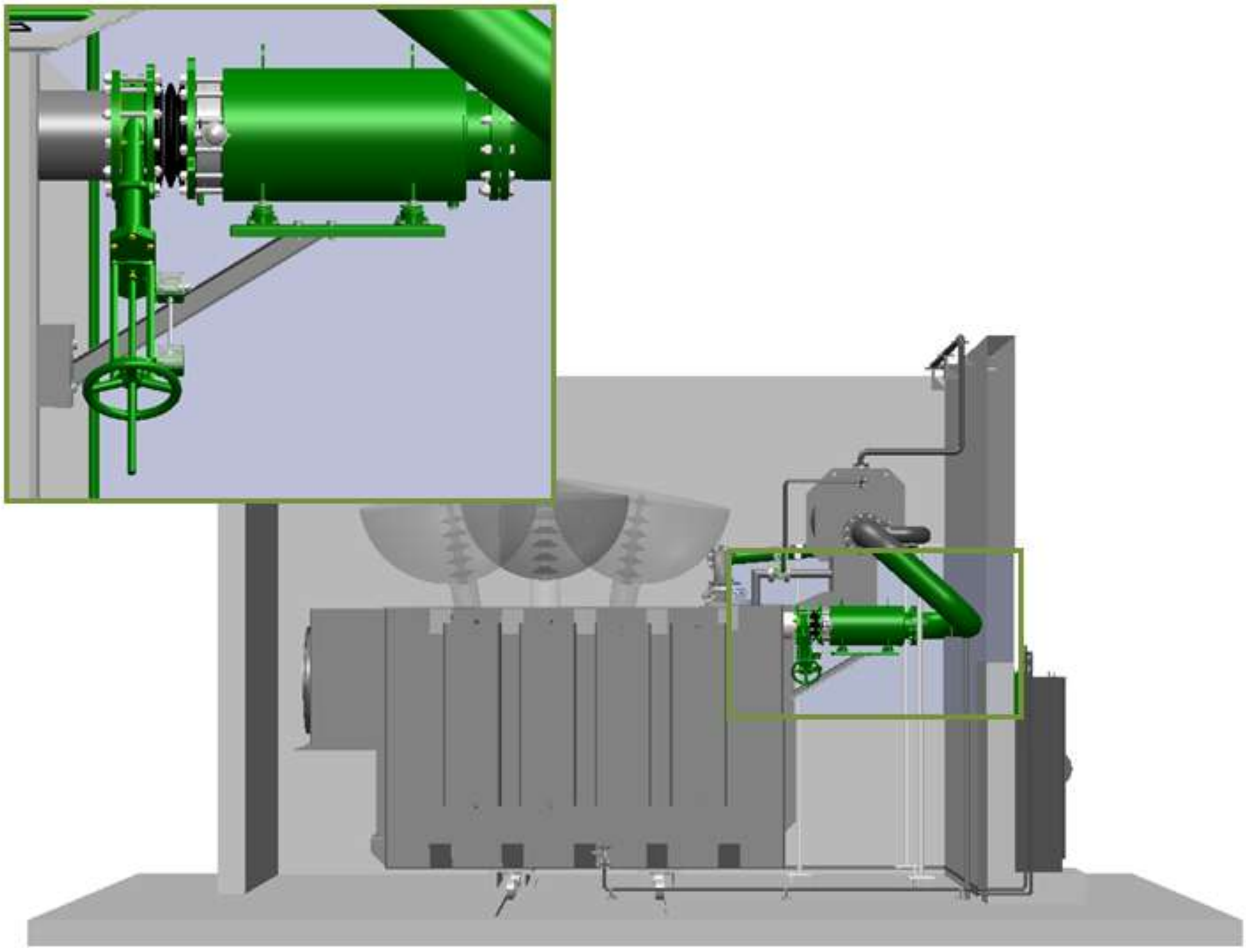


Figure 12: Horizontal Depressurization Set, Front View

The HDS is mounted on a Horizontal Adaptation Piece installed on the transformer wall. The HDS should be installed at the most suitable location based on the space available without interfering with the transformer's subcomponents and away from bushings electrical clearance.

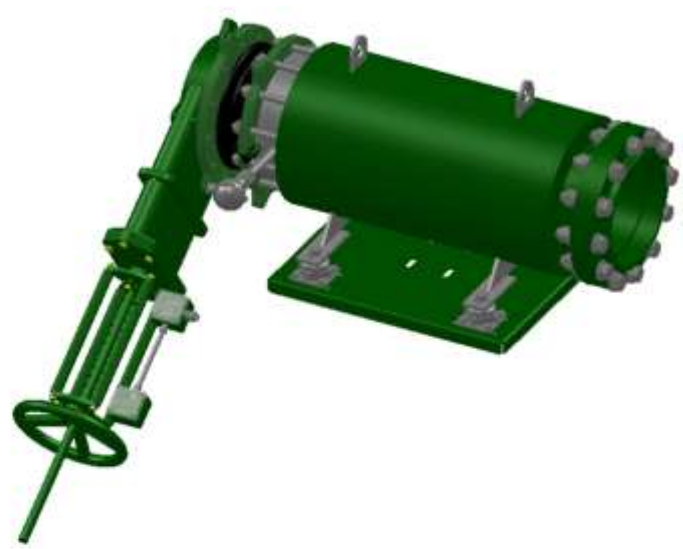


Figure 13: Horizontal Depressurization Set

3 OIL-GAS SEPARATION TANK ARRANGEMENT

3.1 SLICED OIL-GAS SEPARATION TANK STANDARD ARRANGEMENT

The TP Standard Arrangement for the Oil-Gas Separation Tank (OGST) is composed by a Sliced Oil-Gas Separation Tank (SOGST), which is found as part of the transformer conservator tank.

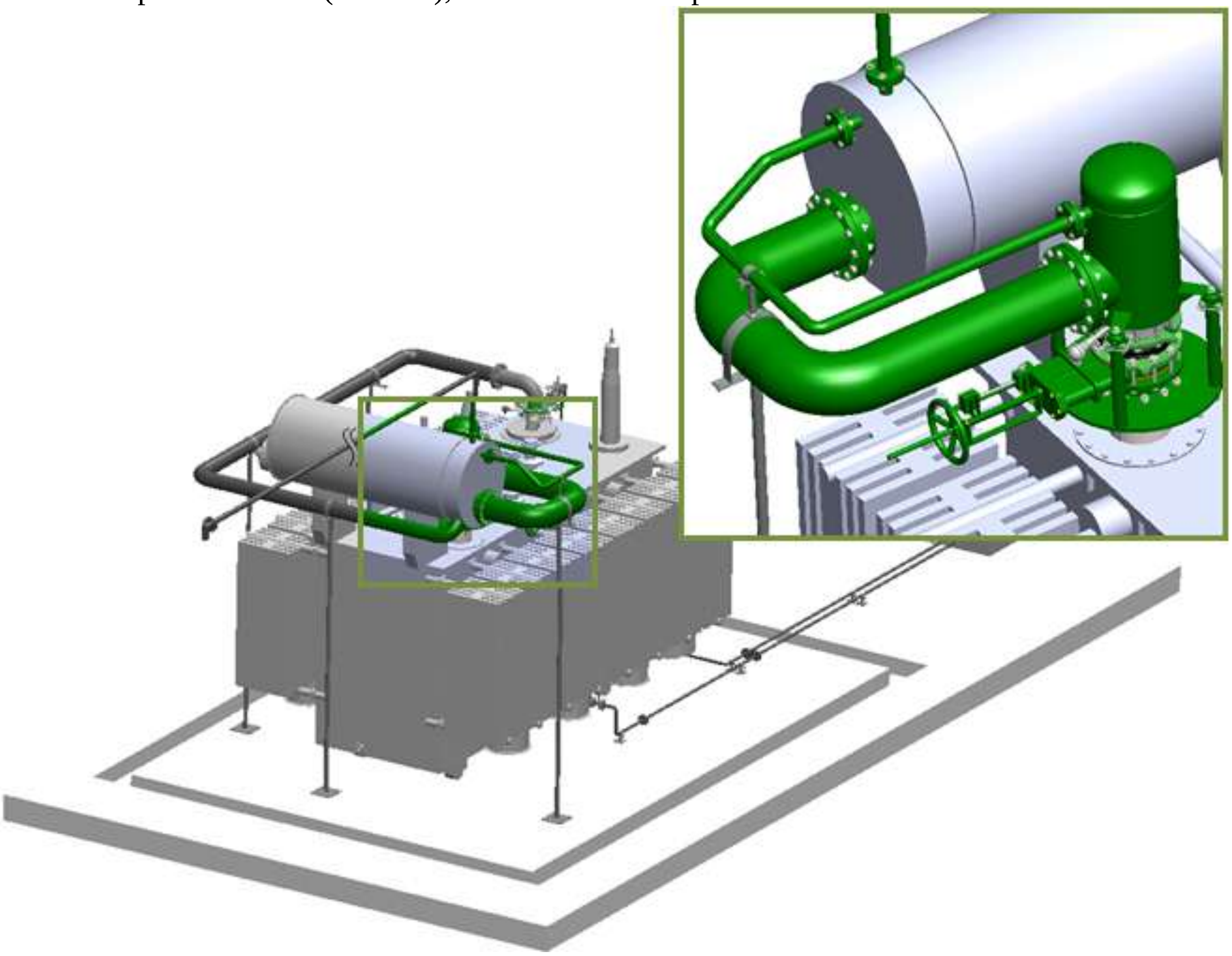
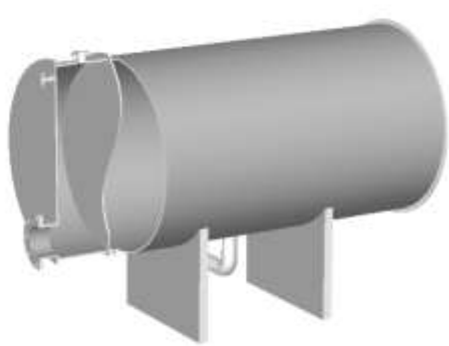


Figure 14: VDS and OLTC DS with SOGST



The SOGST has a minimum volume of 0.5 m^3 (132 gallons) and is a segment of the Conservator Tank specifically reserved for the TP. This segment will collect all expelled oil and explosive gases generated through an inlet on the bottom part of the SOGST. All the explosive gases will be routed to the environment through an interface at the top of the SOGST. The SOGST cannot be shared with other TPs.

Figure 15: Sliced Oil-Gas Separation Tank, Isometric View

3.2 ALTERNATE ARRANGEMENT

There exist two alternatives to substitute the SOGST when constraints are found at the time of confirming the best TP configuration. The first alternative is a Wall mounted Oil-Gas Separation Tank (WOGST) which is mounted to the transformer firewall. The second alternative is an Elevated Oil-Gas Separation Tank (EOGST) which is installed above the transformer conservator tank.

3.2.1 WALL MOUNTED OIL-GAS SEPARATION TANK

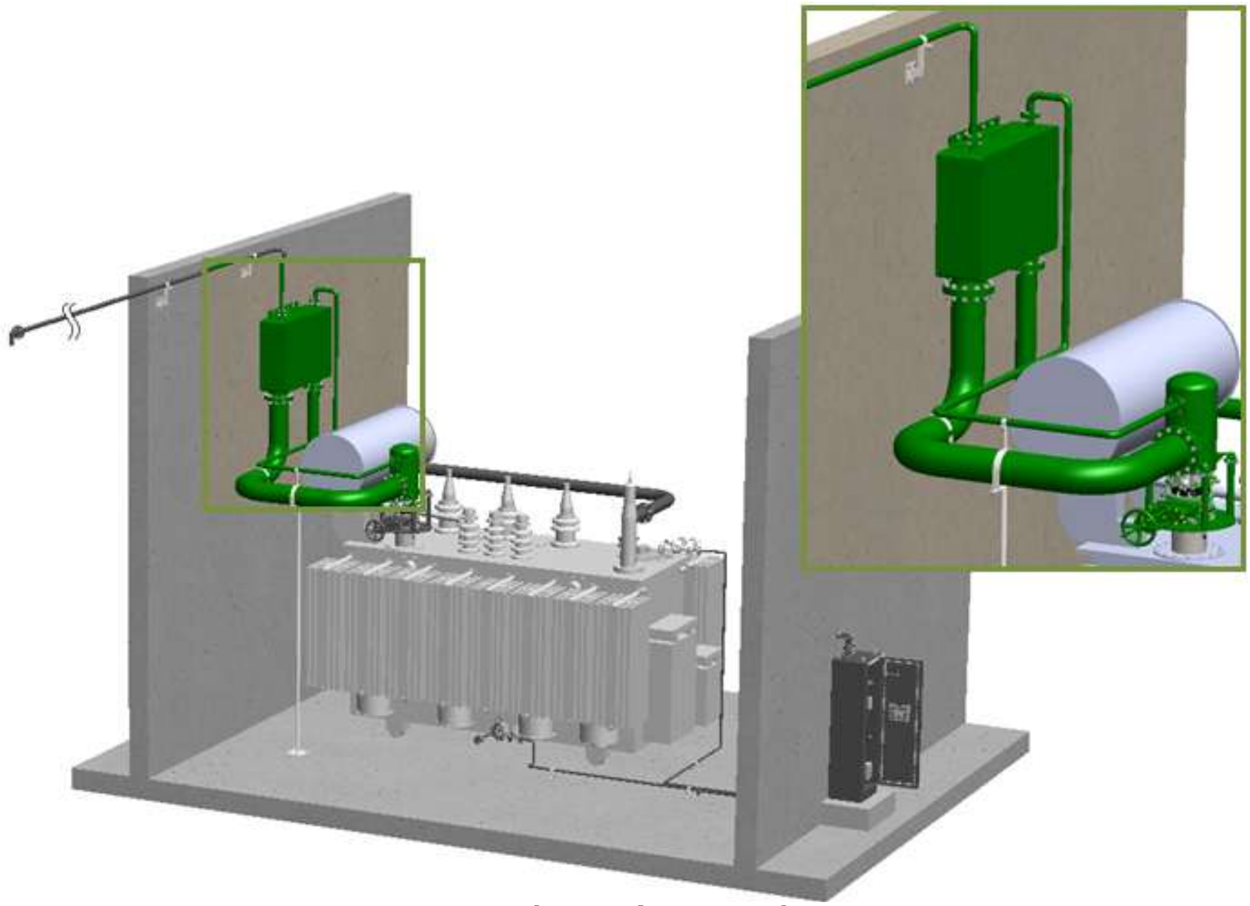


Figure 16: Vertical DS and OLTC with WOGST

The WOGST has a minimum volume of 0.5 m^3 (132 gallons) and should be fixed to the transformer firewall and installed above the transformer conservator tank. The top of the WOGST must be installed at least 100 mm (4-inches) above the highest point of the transformer conservator tank. For nitrogen layer transformers, the bottom of the WOGST must be installed at least 100 mm (4-inches) above the highest point of the highest Depressurization Set. The WOGST cannot be shared with other TPs.

Figure 17: WOGST, Isometric View

3.2.2 ELEVATED OIL-GAS SEPARATION TANK

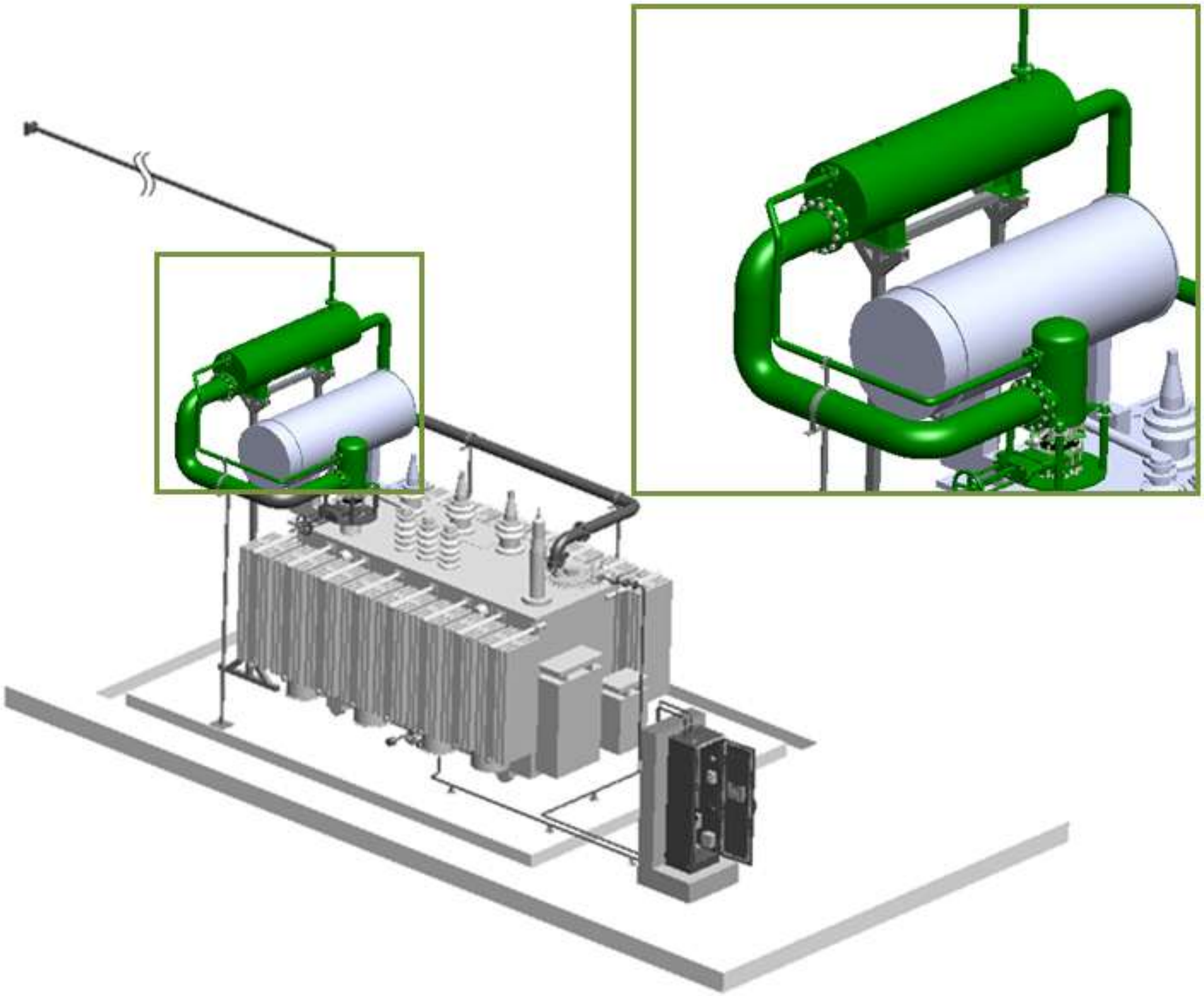


Figure 18: Vertical DS with EOGST

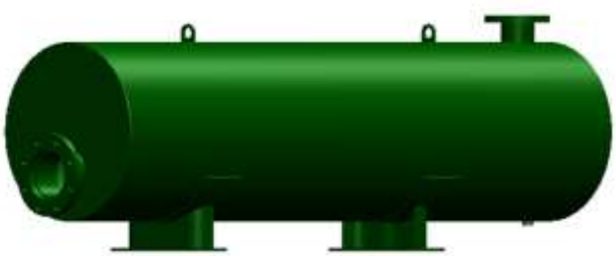


Figure 19: EOGST, Isometric View

The EOGST has a minimum volume of 0.5 m^3 (132 gallons). The EOGST should be supported from the conservator supports, transformer body (based on the transformer design), or the directly from the ground. The bottom of the EOGST must be installed at least 100 mm (4-inches) above the highest point of the transformer conservator tank. For nitrogen layer transformers, the bottom of the EOGST must be installed at least 100 mm (4-inches) above the highest point of the highest Depressurization Set. The EOGST cannot be shared with other TPs.

4 SCOPE OF SUPPLY FOR ADAPTATION

The items provided will depend on the TP model chosen and the options requested by the customer.

TP TYPE	SET	QUANTITY	COMPONENT
TP	DS	1	Nebar Gasket
		1	Isolation Valve
		1	Shock Absorber
		1	Rupture Disk
		1	Nitrile Gasket
		1	Decompression Chamber
		4	Vibration Mounts
		*	Fasteners
	IGIS	1	TP Cabinet
		1	TP Identity Plate
		1	Automatic Trigger for Inert Gas Cylinder
		1	Inert Gas Cylinder
		2	Inert Gas Cylinder Collar Support
		2	Inert Gas Cylinder Collar
		1	Inert Gas Cylinder Base Protection
		1	Manometer
		***	Air Vent
		***	Inert Gas Injection Pipe Non-Return Valve Set
	GEP ***	1	Automatic Ball Valve
		1	Manual Ball Valve
		1	Air Vent
	EGES	1	Air Isolation Shutter
	LHD	1	Three-Way Connection Box
		1	LHD Cable Set
	CB	1	Control Box
		1	Synoptic Plate
A	DS	1	Nebar Gasket
		**	Isolation Valve
		**	Shock Absorber
		1	Rupture Disk
		1	Decompression Chamber
		1	Nitrile Gasket
		*	Fasteners
B	DS	1	Nebar Gasket
		1	Isolation Valve
		1	Shock Absorber
		1	Rupture Disk
		1	Nitrile Gasket
		*	Fasteners
* Varies according to DS size. **Only for External OLTCs. *** Varies according TP type configuration			

Table 1: Standard Components of the TP depending on TP design

Other items not indicated Table 1 may also be provided, depending on the options selected by the client. Refer to the Section 10.8 for a list of items that are not included in the standard scope of supply.

5 DEPRESSURIZATION SET SIZE VERSUS TRANSFORMER POWER

5.1 STANDARD SIZING

The DS is arranged in every case according to the transformer characteristics. The main parameter to take into account in order to determine the size of the DS is the transformer maximum power (MVA), and in the case of Double Failure Protection (optional) the DS must be oversized.

Generation, Transmission and Distribution Transformer Power, MVA	Depressurization Set Size	Sizing for Double Failure (Option)
0.1 MVA < TP ≤ 1 MVA	DN 100 / 4-inch	DN 125 / 5-inch
1 MVA < TP ≤ 4 MVA	DN 125 / 5-inch	DN 150 / 6-inch
4 MVA < TP ≤ 15 MVA	DN 150 / 6-inch	DN 200 / 8-inch
15 MVA < TP ≤ 100 MVA	DN 200 / 8-inch	DN 250 / 10-inch
100 MVA < TP ≤ 300 MVA	DN 250 / 10-inch	DN 300 / 12-inch
300 MVA < TP ≤ 500 MVA	DN 300 / 12-inch	2 x DN 300 / 2 x 12-inch
500 MVA < TP	2 x DN 300 / 2 x 12-inch	N/A

Table 2: Standard Depressurization Set Size for Transformers

Table 3 below represents the DS sizing for the OLTC and the OCB/OBCB according to the transformer TP DS size.

<table>
<tr><th>Transformer DS Size</th><th>OLTC DS Size
(Internal/External OLTC)</th><th>OCB/OBCB DS Size</th></tr>
<tr><td>DN150 (6in)</td><td rowspan="4">DN150 (6in)</td><td>DN150 (6in)</td></tr>
<tr><td>DN200 (8in)</td><td>DN150 (6in)</td></tr>
<tr><td>DN250 (10in)</td><td>DN200 (8in)</td></tr>
<tr><td>DN300 (12in)</td><td>DN250 (10in)</td></tr>
</table>

Table 3: DS size of the OLTC and OCB/OBCB according to the Transformer DS Size

6 TRANSFORMER INTERFACES ANALYSIS

6.1 GENERAL OVERVIEW

In order to install the TP, transformer and sub-components interfaces must be carefully analyzed.

1. Sensors, detectors, and electrical connections;
2. Electrical clearance;
3. Transformer tank compartments;
4. DS and IGIS;
5. ODP connection to the OGST.

The DS and IGIS are directly linked to the transformer tank. The transformer manufacturer should provide the connections to adapt the DS and IGIS.

The installation company is responsible of ensuring all components are properly installed and that the installation of the entire TP is completed as per the TP specifications.

The installation company is in charge of installing:

- all DS to the transformer or specific component,
- ODP to the OGST from all DS,
- GEP to the OGST from its required location,
- OGST,
- EGEP from the OGST to a remote area far away from the transformer and surrounding equipment,
- TP Cabinet,
- IGIP from the TP Cabinet to the transformer, OLTC (if applicable), and OCB (if applicable),
- Linear Heat Detector,
- Control Box,
- Interconnection Box,
- Piping supports,
- all required cables,
- all valves,
- etc.

An organization plan must be carefully prepared in order to minimize transformer shutdown time. In spite of this procedure, it is strongly recommended to request guidance for the TP installation.

6.2 ADAPTATION PIECE

The DS Adaptation Piece elements are a standard steel grade flange and pipe. Both are welded together, constructing the DS Adaptation Piece. The size of the Adaptation Piece will correspond to the Depressurization Set size and the geometry will vary depending on the TP configuration type.

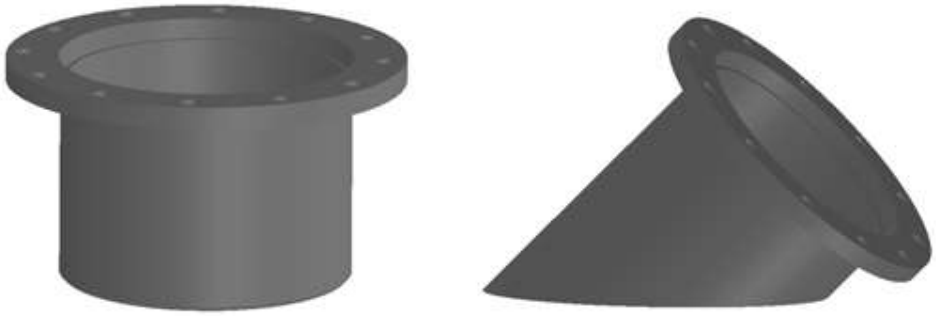


Figure 20: DS Adaptation Piece

6.2.1 DEPRESSURIZATION SET

The transformer Adaptation Piece must be welded onto the transformer tank. The maximum distance between the transformer tank and the outer surface of the Adaptation Piece flange must not exceed 250 mm (9.8-inch) as maximum length.

The DS position on the transformer cover must be decided in agreement with the customer and transformer manufacturer, since an electrical and mechanical interference may occur if the DS is too close to the bushings.

Particular attention should be given to the electrical clearance before installing a DS. The TP configuration must always be confirmed and approved by the Project Department.

The efficiency of the TP is directly dependent on the distance between the Rupture Disk and the transformer tank main cover or transformer tank wall (this depends on the type of DS chosen). Thus the following three items must be respected otherwise the TP efficiency will be sharply reduced and the TP guarantee will be withdrawn.

1. **No additional valve may be positioned before or after the TP Isolation Valve;**
2. **No other valve may be used to substitute the TP Isolation Valve between the transformer tank and the DS;**
3. **The distance between the transformer tank main cover or wall and the TP Isolation Valve must not exceed the distances described in this document.**

6.2.2 VERTICAL DEPRESSURIZATION SET

6.2.2.1 General Overview

The VDS is arranged to fit on transformer covers. The VDS can be supplied in advance to allow the client to make the vacuum and fill the transformer with oil, and will not represent a problem for the transformer manufacturer when performing the normal transformer oil filling during and once the TP has been installed. The transformer manufacturer can perform the vacuum of the transformer with the Isolation Valve opened or closed.

6.2.2.2 Vertical DS - Adaptation Piece

The transformer manufacturer should manufacture and install the VDS Adaptation Piece. The location of the VDS Adaptation Piece should be selected according to the location of the OGST, which will help minimize the amount of ODP and GEP needed for the TP installation.

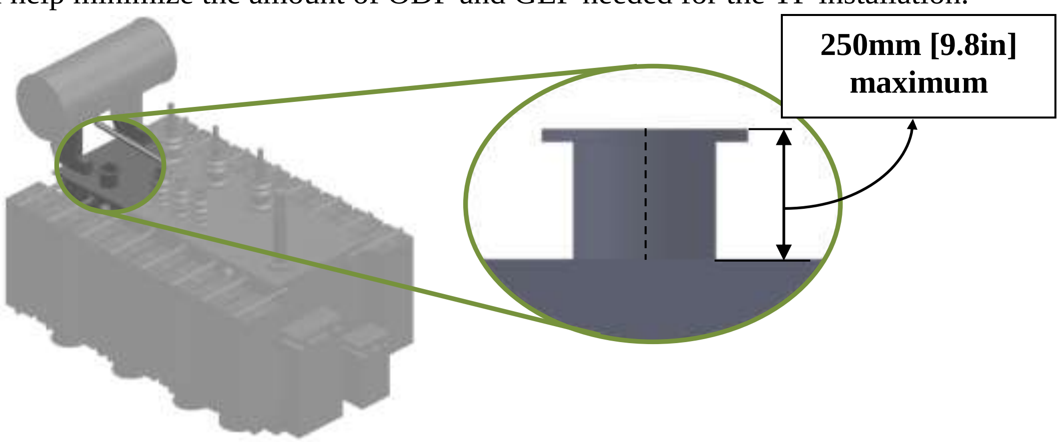


Figure 21: Vertical DS Adaptation Piece

6.2.3 45° DEPRESSURIZATION SET

6.2.3.1 General Overview

The 45°DS should be installed only when no possibilities exist to install a VDS. The location of the 45°DS adaptation should be selected according to the location of the OGST in order to minimize the amount of ODP, as per the TP configuration piping installation layout, and according to the space available.

6.2.3.2 45° DS Adaptation – Adaptation Piece

The transformer manufacturer should manufacture and install provide the 45°DS Adaptation Piece.

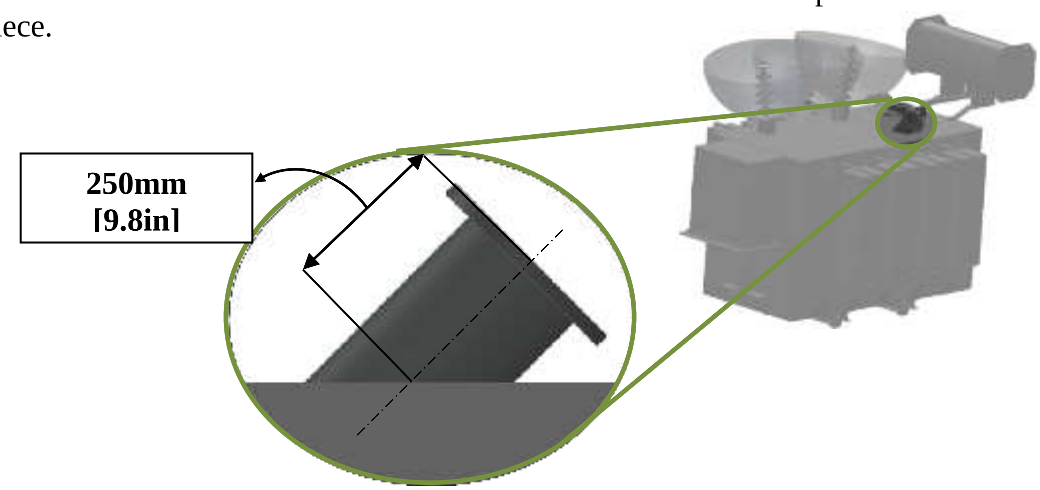


Figure 22: 45° DS Adaptation Piece

6.2.4 HORIZONTAL DEPRESSURIZATION SET

6.2.4.1 General Overview

The HDS should be installed only when no possibilities exist to install a VDS or a 45°DS. The HDS should be adapted on the transformer wall as per the most suitable location, as per the TP configuration piping installation layout, according to the space available, and according to the location of the OGST in order to minimize the amount of ODP.

6.2.4.2 Horizontal DS – Adaptation Piece

The transformer manufacturer should manufacture and install the HDS Adaptation Piece.

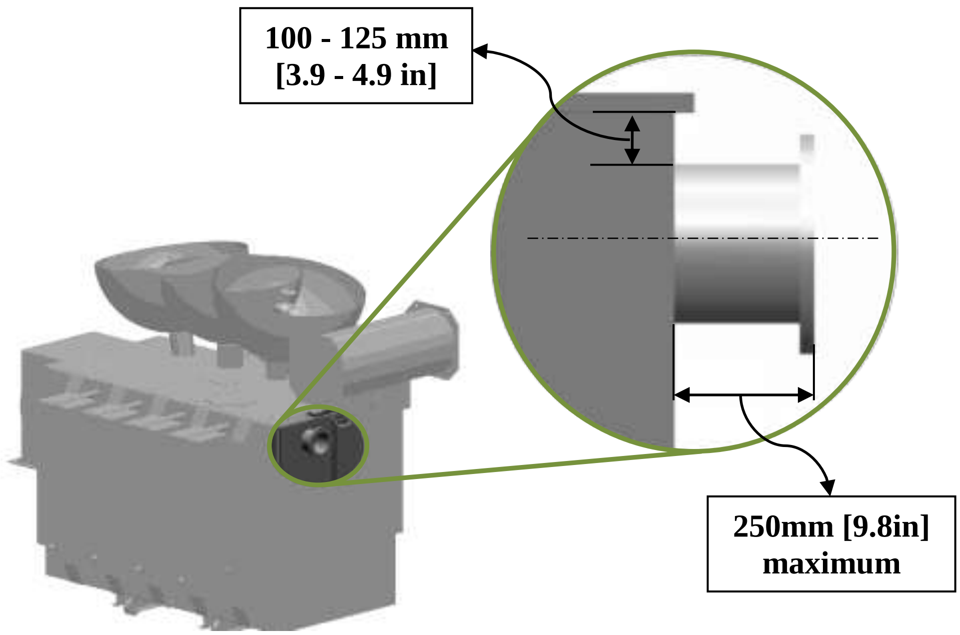


Figure 23: Horizontal DS Adaptation Piece

6.2.5 Internal On Load Tap Changer Depressurization Set

6.2.5.1 General Overview

In order to fit an On Load Tap Changer (OLTC) with the TP, the OLTC must be equipped with a DN 150 (6-inch) flange on the cover or on the casing in order to adapt the DS. The OLTC will have to be equipped with a DN 25 (1-inch) connection for the IGIP, which will allow the inert gas to be injected to the bottom of the OLTC.

IMPORTANT: The material of the OLTC cover must be reinforced steel in order to withstand the weight of the DS. If the OLTC cover is not reinforced steel, an OLTC DS support must be installed, see Section 7.1.5. Contact SERGI France to submit OLTC type, cover material, and additional information.

For OLTCs only, the PRV can be replaced by the DS, as there is no need to have a PRV thus the static pressure will always be regulated by a flow of oil between the OLTC and the OLTC Conservator.

6.2.6 Internal OLTC Adaptation Piece Development

The OLTC manufacturer should manufacture and install the Internal OLTC DS Adaptation Piece, in which the location should be selected according to the location of the OGST in order to minimize the amount of ODP.

The OLTC Adaptation Piece must be welded onto the Internal OLTC. The maximum distance between the OLTC cover and the outer surface of the Adaptation Piece flange must not exceed 170 mm (6.7-inch) as maximum length.

The DS position on the OLTC cover must be decided in agreement with the customer and transformer manufacturer, since an electrical and mechanical interference may occur if the DS is too close to the bushings. The TP configuration must be always confirmed and approved by TPC.

Particular attention should always be given to the electrical clearance before installing the Internal OLTC DS. The TP configuration must always be confirmed and approved by the Project Department.

No valve may be installed before or after the DS.

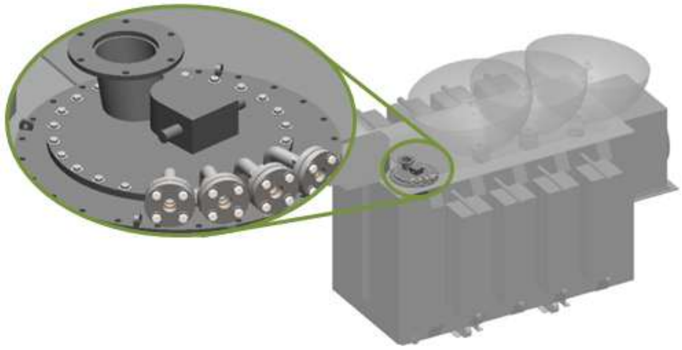


Figure 24: Adaptation to Internal OLTC (MR Type) DS

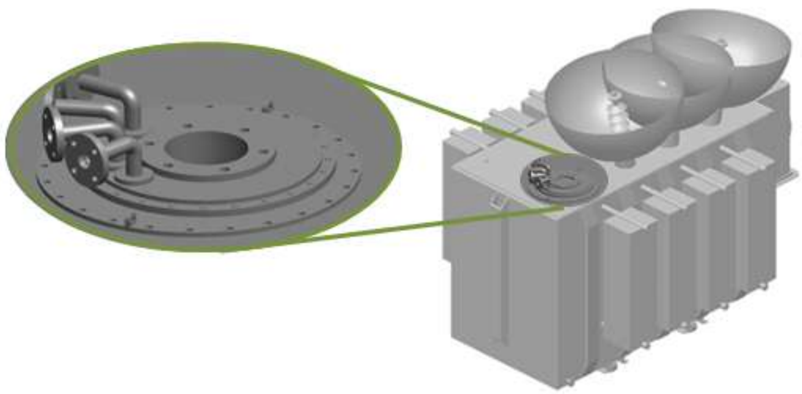


Figure 25: Adaptation to Internal OLTC (ABB Type) DS

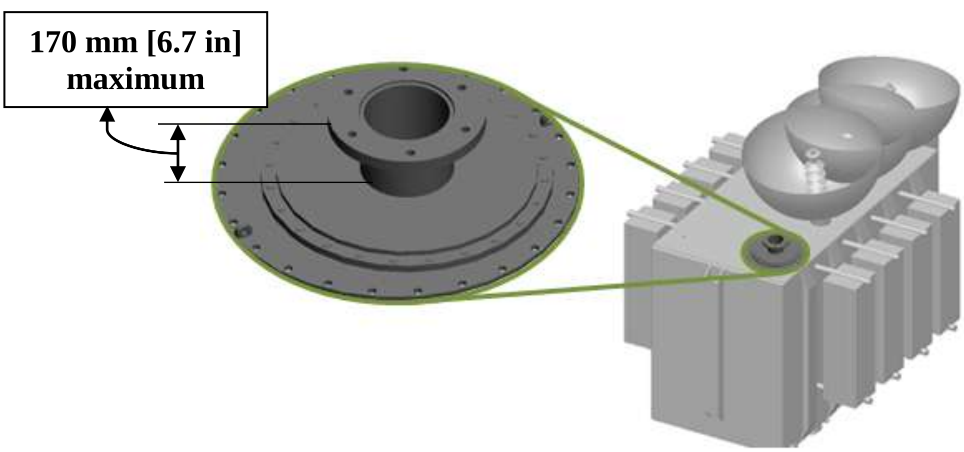


Figure 26: Adaptation to Internal OLTC DS

6.2.7 External OLTC Depressurization Set

6.2.7.1 General Overview

The External OLTC DS consist of an Isolation Valve which can be supplied in advance to allow the client to make the vacuum and fill the External OLTC with oil. The External OLTC DS will not represent a problem for the transformer manufacturer when performing the normal transformer oil filling, during and once the TP has been installed.

6.2.7.2 External OLTC Adaptation Pipe and Flange Development

The transformer manufacturer should manufacture and install the External OLTC DS Adaptation Piece, in which the location should be selected according to the location of the OGST in order to minimize the amount of ODP.

The OLTC Adaptation Piece must be welded onto the External OLTC. The maximum distance between the OLTC cover/wall and the outer surface of the Adaptation Piece flange must not exceed 250 mm (9.8-inch) as maximum length.

The DS position on the OLTC cover must be decided in agreement with the customer and transformer manufacturer, since an electrical and mechanical interference may occur if the DS is too close to the bushings. The TP configuration must be always confirmed and approved by SERGI France.

Particular attention should be given to the electrical clearance before installing the External OLTC DS.

It is of the utmost importance that no other valve other than the IV is fitted between the OLTC and the DS, otherwise the TP efficiency will be sharply reduced and the TP guarantee will be withdrawn.

The External OLTC cover must be made of reinforced steel in order to withstand the weight of the DS.

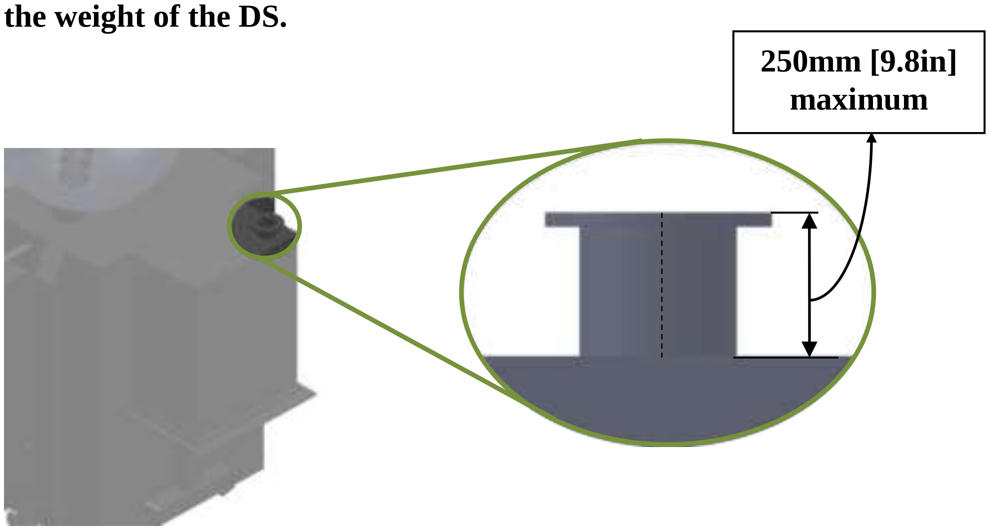


Figure 27: External OLTC DS Adaptation Piece

6.2.8 Oil Cable Box / Oil Bushing Cable Box Depressurization Set

6.2.8.1 General Overview

The OCB/OBCB DS consist of an Isolation Valve which can be supplied in advance to allow the client to make the vacuum and fill the OCB/OBCB with oil. The OCB/OBCB DS will not represent a problem for the transformer manufacturer when performing the normal transformer oil filling during and once the TP has been installed.

6.2.8.2 OCB/OBCB Adaptation Pipe and Flange Development

The transformer manufacturer should manufacture and install the OCB/OBCB DS Adaptation Piece, in which the location should be selected according to the location of the OGST in order to minimize the amount of ODP. The TP can be installed either on the top or the side of the OCB/OBCB.

The OCB/OBCB Adaptation Piece must be welded onto the OCB/OBCB. The maximum distance between the OCB/OBCB wall and the outer surface of the Adaptation Piece flange must not exceed 250 mm (9.8-inch) as maximum length.

The DS position on the OCB/OBCB wall must be decided in agreement with the customer and transformer manufacturer, since an electrical and mechanical interference may occur. The TP configuration must be always confirmed and approved by SERGI France.

It is of the utmost importance that no other valve other than the Isolation Valve is fitted between the OCB/OBCB and the DS, otherwise the TP efficiency will be sharply reduced and the TP guarantee will be withdrawn.

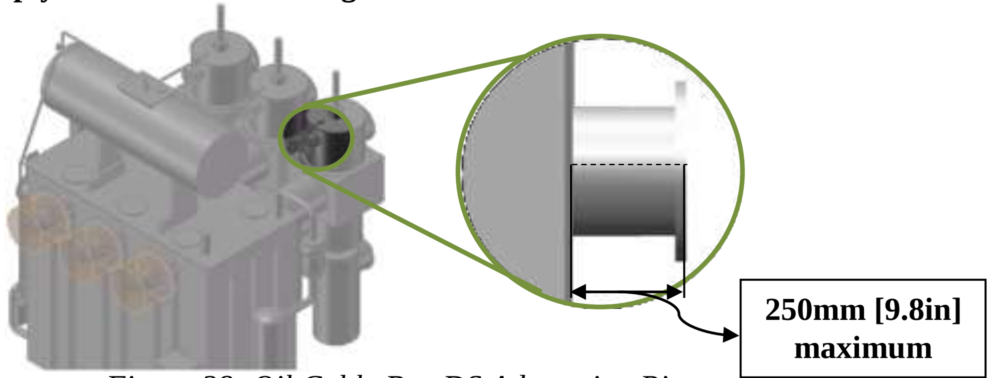


Figure 28: Oil Cable Box DS Adaptation Piece

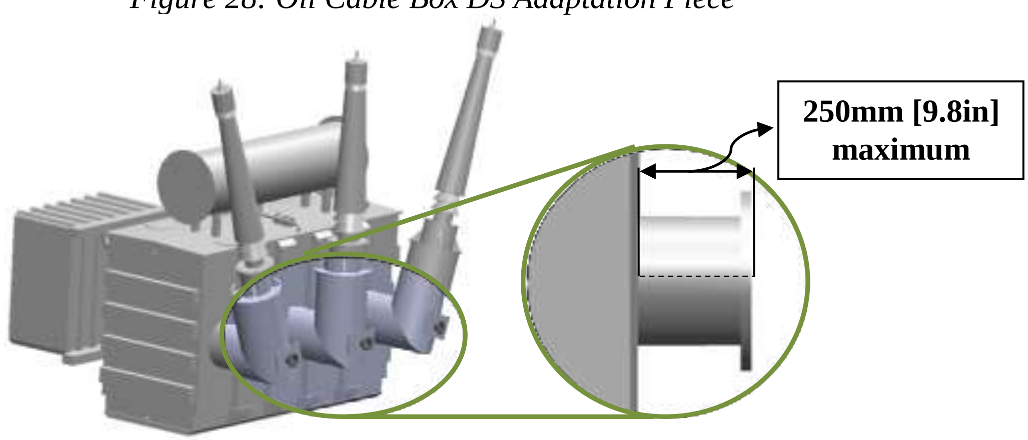


Figure 29: Oil Bushing Cable Box DS Adaptation Piece

6.2.9 INERT GAS INJECTION

6.2.9.1 Inert Gas Injection for Transformer

The transformers will have to be equipped with one connection for the IGIP. The connection's minimum diameter must be DN25 (1-inch). The connection must be found at the transformer bottom. A ball valve must be installed at the connection. This ball valve will allow connecting and isolating the transformer from the IGIP during transformer maintenance.

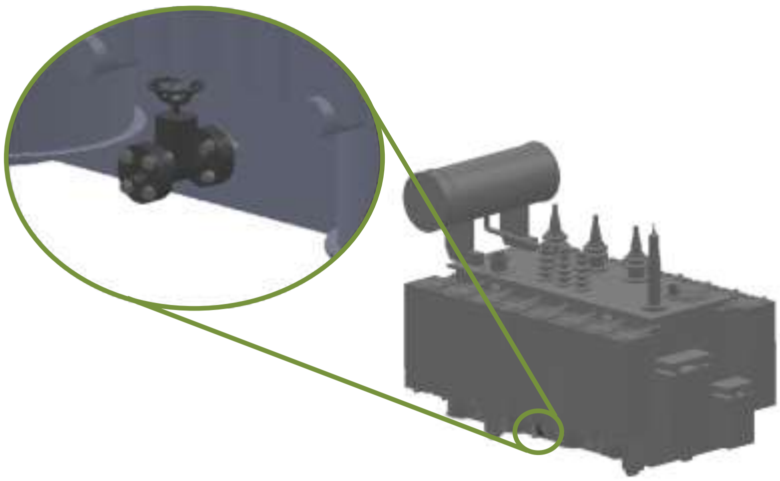


Figure 30: Transformer Inert Gas Injection Connection

6.2.9.2 Inert Gas Injection for Internal OLTC

The OLTC will have to be equipped with one connection for the IGIP. The connection minimum diameter must be DN25 (1-inch). The IGIP is to be connected to the drain valve turret found on the Internal OLTC cover (must be connected to a turret which will allow for the inert gas to be injected to the bottom of the OLTC). A ball valve will have to be supplied at this connection point to isolate the OLTC and IGIS from each other during maintenance operations.

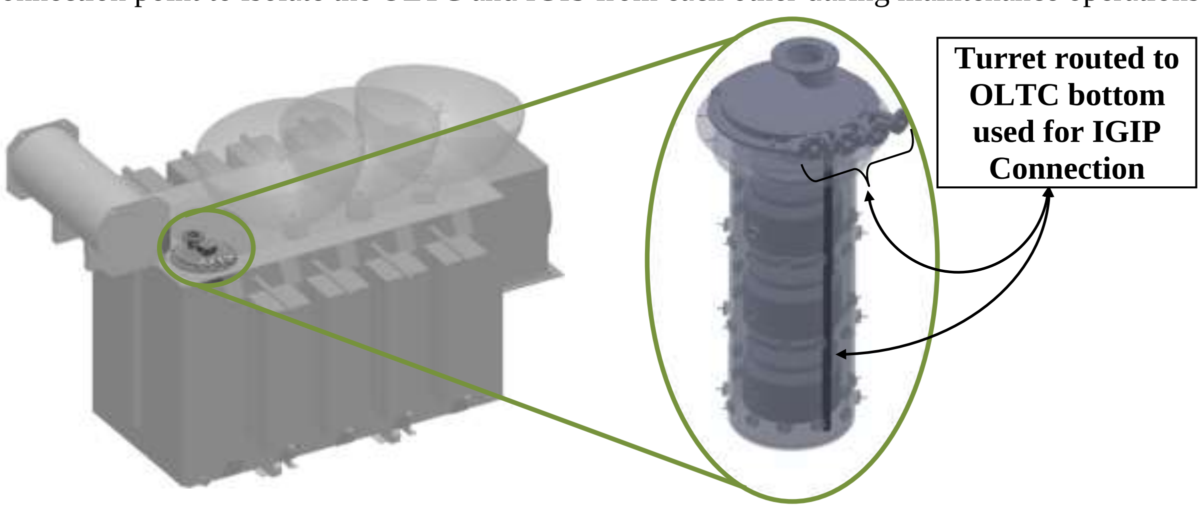


Figure 31: OLTC Inert Gas Injection Connection

6.2.9.3 Inert Gas Injection for External OLTC

The External OLTC will have to be equipped with one connection for the IGIP. The minimum connection diameter must be DN25 (1-inch). The connection is to be found at the bottom of the External OLTC. A ball valve will have to be supplied at this connection point to isolate the External OLTC and IGIS from each other during maintenance operations.

6.2.9.4 Inert Gas Injection for OCB

The OCB will have to be equipped with one connection for the IGIP. The minimum connection diameter must be DN25 (1-inch). The connection is to be found at the bottom of the OCB. A ball valve will have to be supplied at this connection point to isolate the OCB and IGIS from each other during maintenance operations.

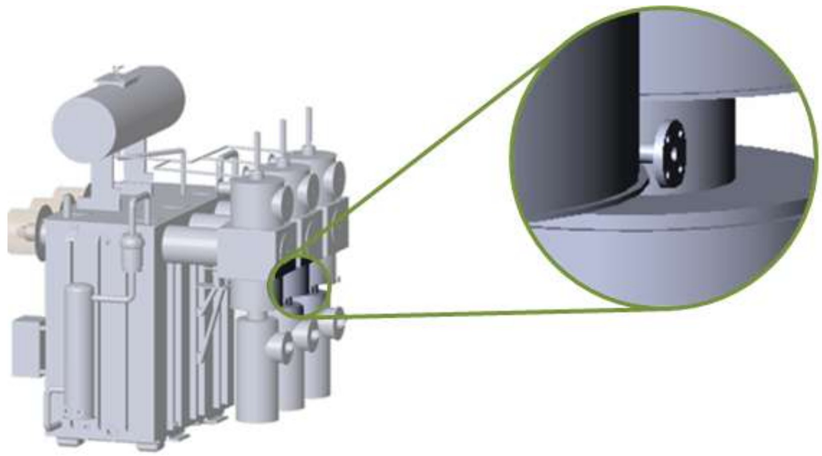


Figure 32: OCB Inert Gas Injection Connection

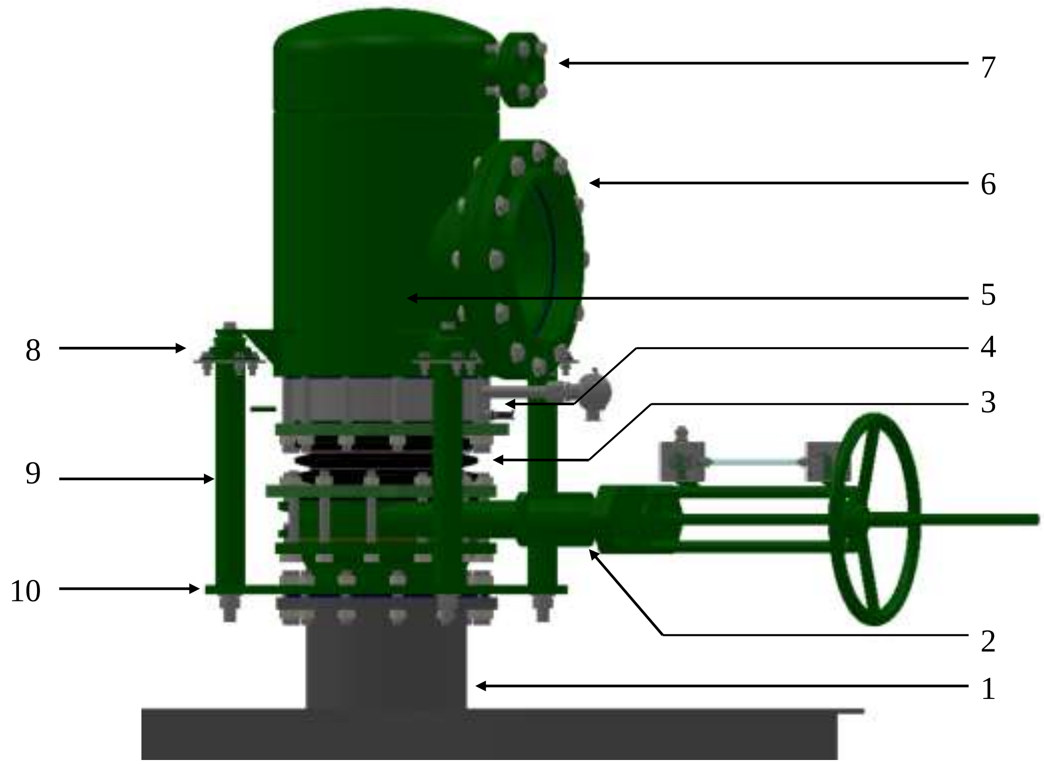
6.2.10 TP TRANSFORMER ELECTRICAL CONNECTIONS

All TP electrical connections will need to be connected to an electrical interconnection box. The TP Component electrical signals will connect to the interconnection box, which will then be directed to the Control Box (to be installed in the control room).

7 TP COMPONENT DESCRIPTION

7.1 DEPRESSURIZATION SET

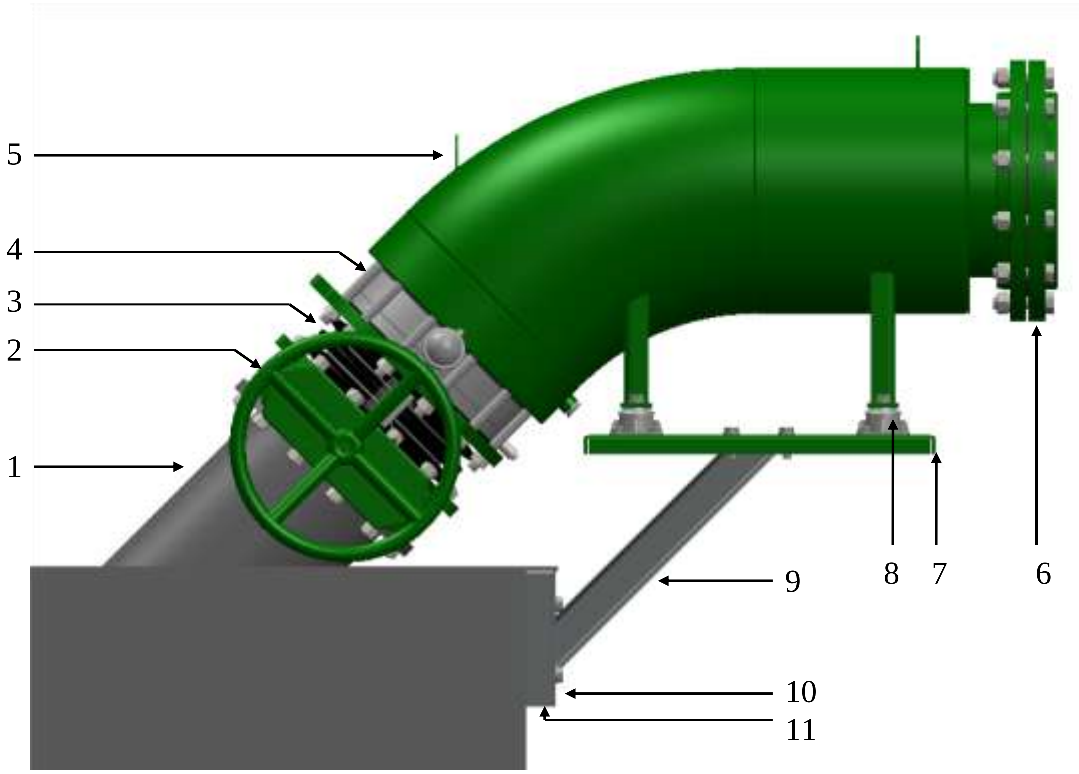
7.1.1 VERTICAL DEPRESSURIZATION SET



NO.	DESCRIPTION
1	Adaptation Piece
2	Isolation Valve
3	Shock Absorber
4	Rupture Disk
5	Decompression Chamber
6	Oil Drain Pipe Outlet
7	Gas Evacuation Pipe Outlet
8	Vibration Absorber
9	DS support Rod
10	DS Support Base

Figure 33: Vertical Depressurization Set

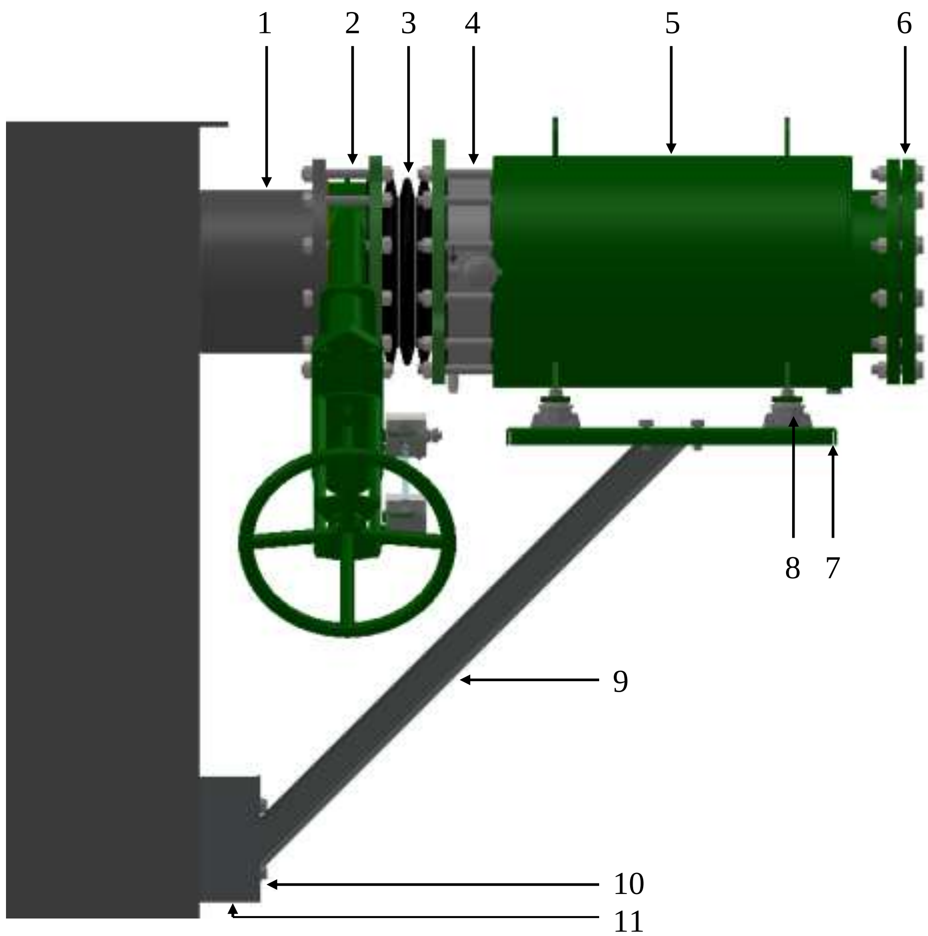
7.1.2 45° DEPRESSURIZATION SET



NO.	DESCRIPTION
1	Adaptation Piece
2	Isolation Valve
3	Shock Absorber
4	Rupture Disk
5	Decompression Chamber
6	Oil Drain Pipe Outlet
7	Support Plate
8	Vibration Absorber
9	Depressurization Set Support
10	Mounting Plate
11	Mounting Bracket

Figure 34: 45° Depressurization Set

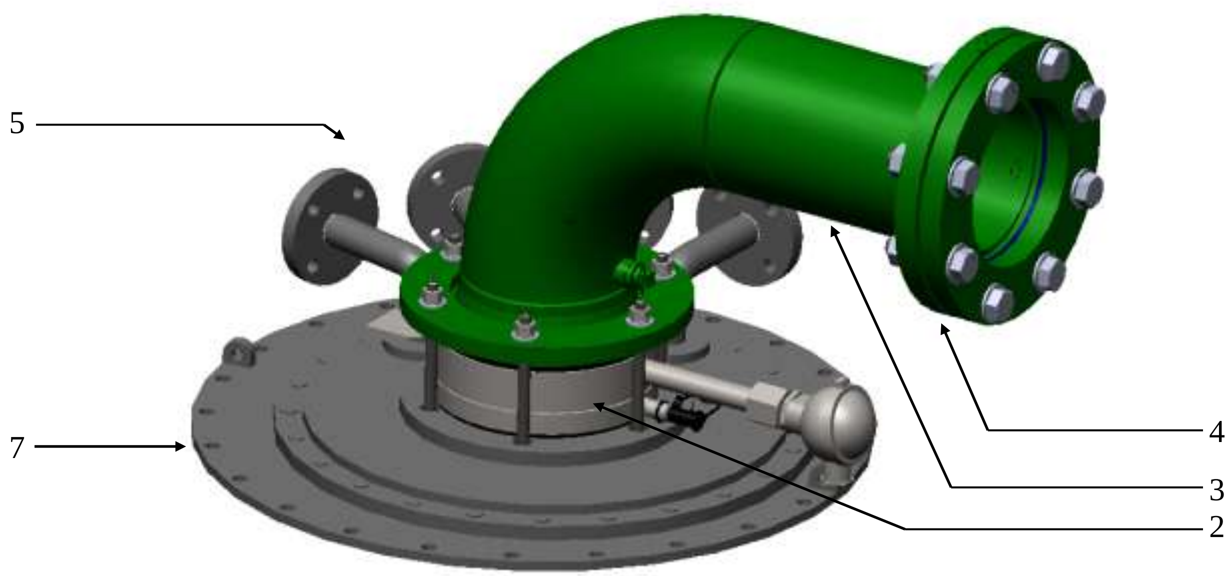
7.1.3 HORIZONTAL DEPRESSURIZATION SET

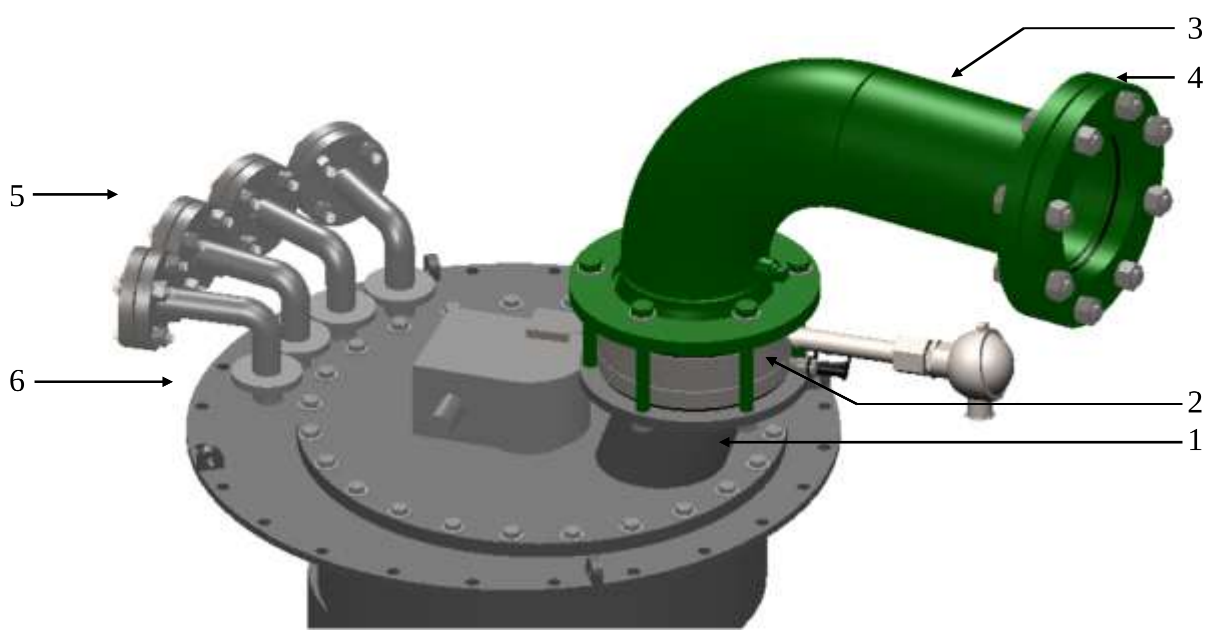


NO.	DESCRIPTION
1	Adaptation Piece
2	Isolation Valve
3	Shock Absorber
4	Rupture Disk
5	Decompression Chamber
6	Oil Drain Pipe Outlet
7	Support Plate
8	Vibration Absorber
9	Depressurization Set Support
10	Mounting Plate
11	Mounting Bracket

Figure 35: Horizontal Depressurization Set

7.1.4 INTERNAL OLTC DEPRESSURIZATION SET WITH STEEL COVER



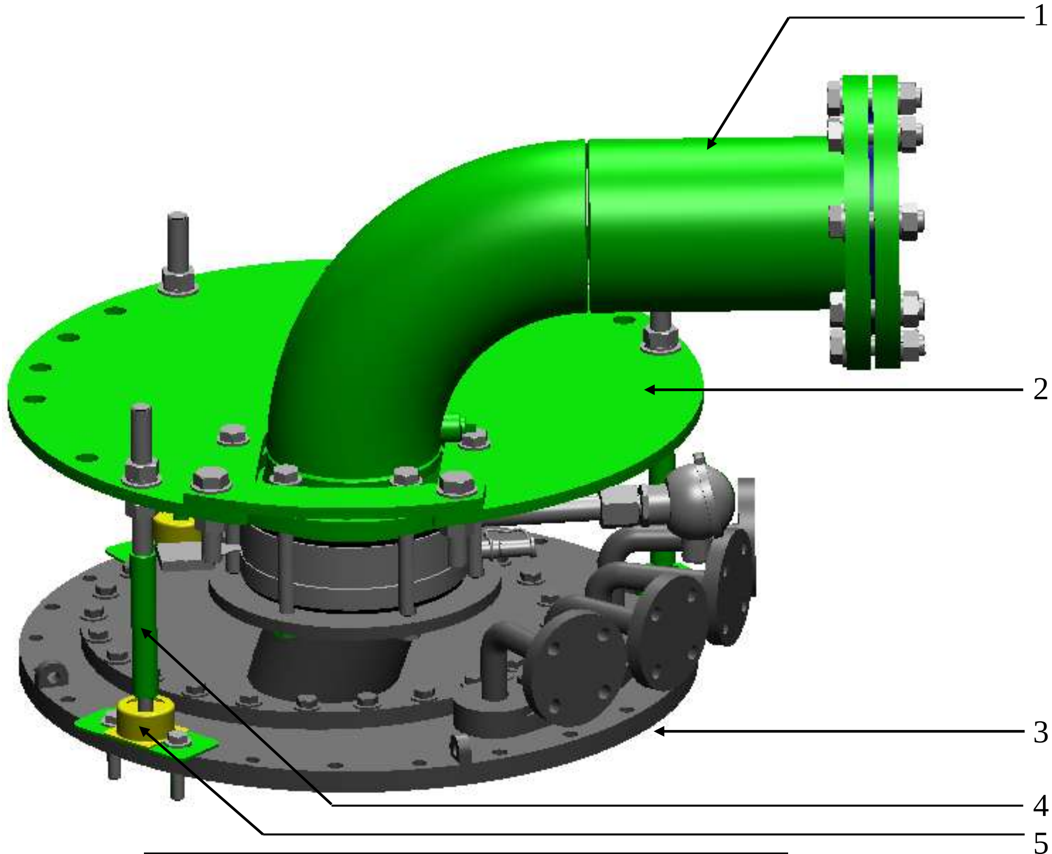


NO.	DESCRIPTION
1	Adaptation Piece
2	Rupture Disk
3	Decompression Chamber
4	Oil Drain Pipe Outlet
5	IGIP Connection (need to identify which connection according to OLTC manufacturer)
6	OLTC cover MR Type
7	OLTC cover ABB Type

Figure 36: ABB and MR On Load Tap Changer Depressurization Set

7.1.5 Internal OLTC DS Support for Aluminum Cover OLTC

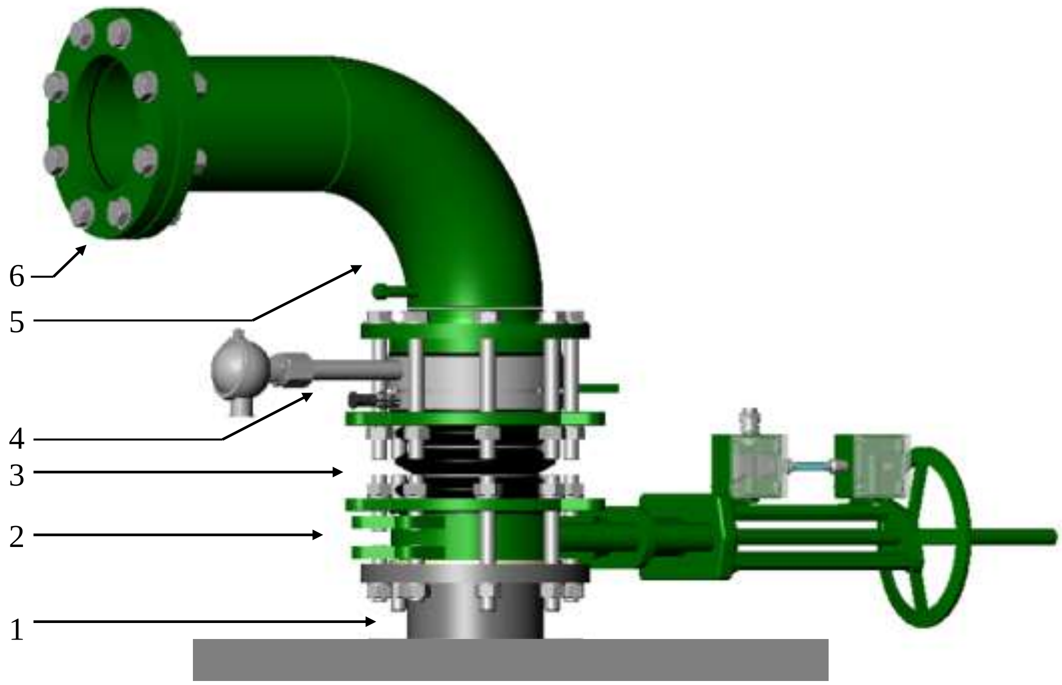
If the MR OLTC cover material consists of aluminum, then an Internal OLTC DS must be supported with a support such as the one found in Figure 37. The type of MR OLTC and certain dimensions will be required in order to properly design the OLTC DS Support.



NO.	DESCRIPTION
1	OLTC DS
2	Support Plate for MR OLTC
3	MR OLTC Aluminum Cover
4	Long Threaded Rod
5	Vibration Isolator

Figure 37: Aluminium cover On Load Tap Changer Depressurization Set with support

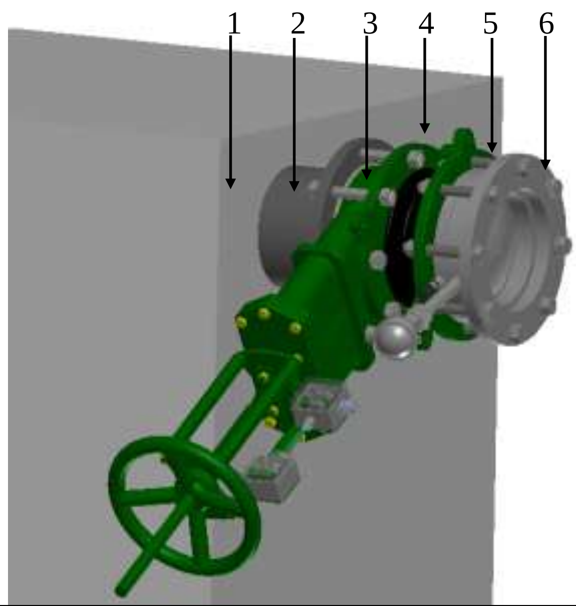
7.1.6 EXTERNAL OLTC DEPRESSURIZATION SET



NO.	DESCRIPTION
1	Adaptation Piece
2	Isolation Valve
3	Shock Absorber
4	Rupture Disk
5	Decompression Chamber
6	Oil Drain Pipe Outlet

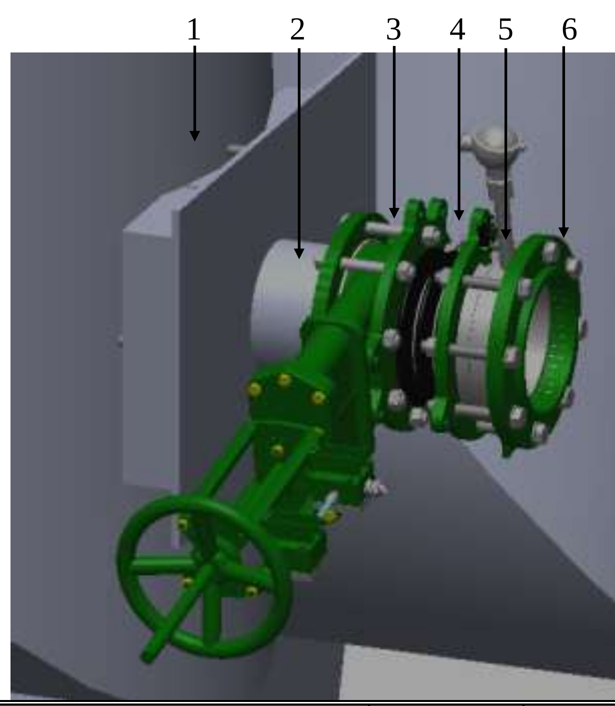
Figure 38: External OLTC Depressurization Set

7.1.7 OIL CABLE BOX DEPRESSURIZATION SET



NO.	DESCRIPTION	NO.	DESCRIPTION
1	Oil Cable Box	4	Shock Absorber
2	Adaptation Piece	5	Rupture Disk
3	Isolation Valve	6	Oil Drain Pipe Outlet

Figure 39: Oil Cable Box Depressurization Set

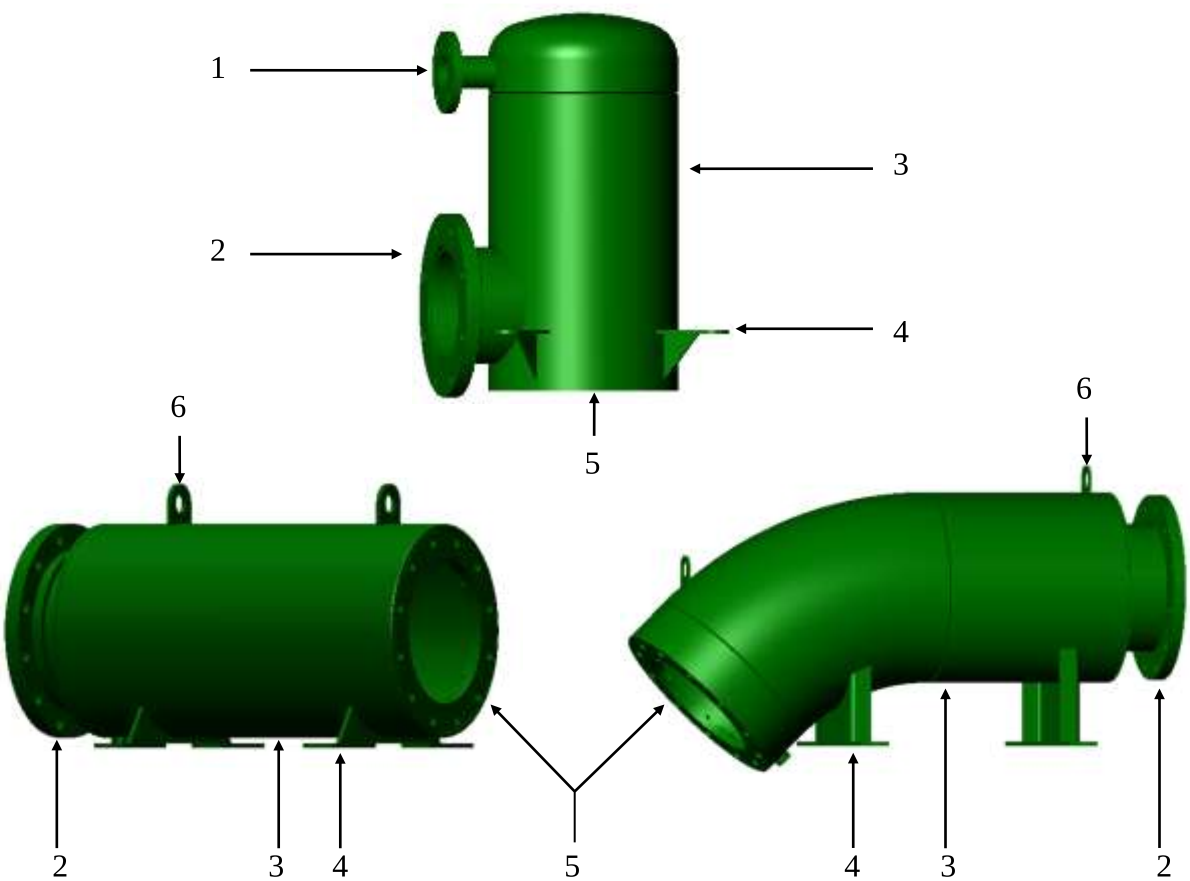


NO.	DESCRIPTION	NO.	DESCRIPTION
1	Oil Bushing Cable Box (Bushing Turret)	4	Shock Absorber
2	Adaptation Piece	5	Rupture Disk
3	Isolation Valve	6	Oil Drain Pipe Outlet

Figure 40: Oil Cable Box Depressurization Set

7.2 DECOMPRESSION CHAMBER

The Decompression Chamber will allow the pressure reduction eliminating the wave of pressure generated by the dynamic pressure inside the transformer in the case of an event.



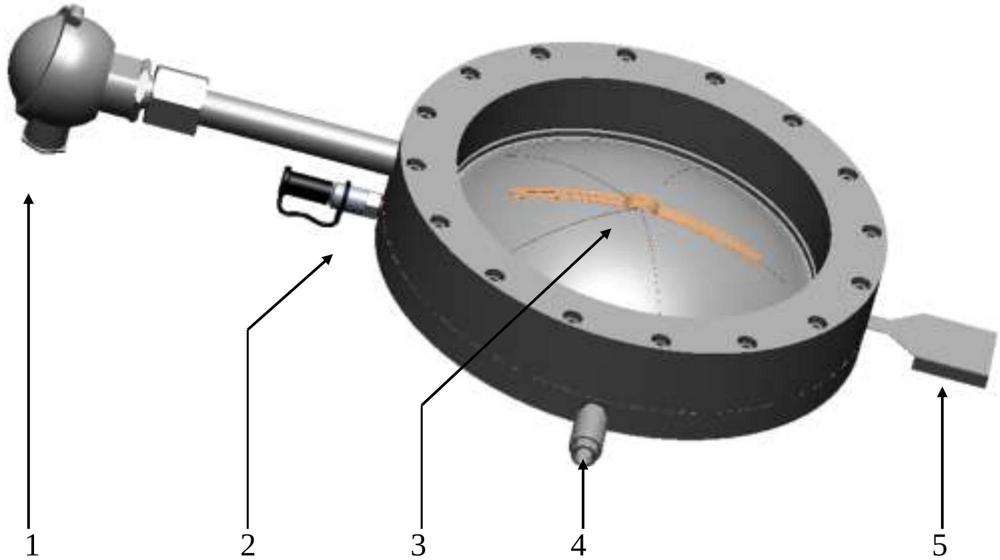
NO.	DESCRIPTION
1	Gas Evacuation Pipe Connection
2	Oil Drain Pipe Connection
3	Decompression Chamber
4	Vibration Mount Support Connection
5	Rupture Disk Connection
6	Lifting Connections

Figure 41: Vertical, Horizontal, and 45° Decompression Chamber

The Decompression Chamber consists of galvanized steel; or stainless steel if it is requested by the customer as an option. The Decompression Chamber will have prepared outlet with fasteners, gaskets, and flanges ready to connect the ODP.

7.3 RUPTURE DISK

The Rupture Disk is permanently in contact with transformer oil during normal transformer operation. The Rupture Disk will be considered the weakest point of the transformer, opening with the dynamic pressure waves of an electrical short-circuit. The Rupture Disk is custom made and calibrated with the consideration of parameters that specifically apply for each transformer.



NO.	DESCRIPTION
1	Connection Head
2	Vacuum Connection
3	Single Rupture Disk Burst Indicator
4	Rupture Disk Over Pressure Protection
5	ID Tag

Figure 42: Rupture Disk

When the TP is activated, an electrical signal given by one or two (option) Burst Indicators shall send the Rupture Disk opening signal to the Control Box. The cover on the Rupture Disk Connection Head is removed allowing access to the Rupture Disk electrical connection. The Rupture Disk also consists of a Rupture Disk Over Pressure Protection (RDOPP) which avoids the RD to open with the oil expansion when the IV is closed.

7.4 SHOCK ABSORBER

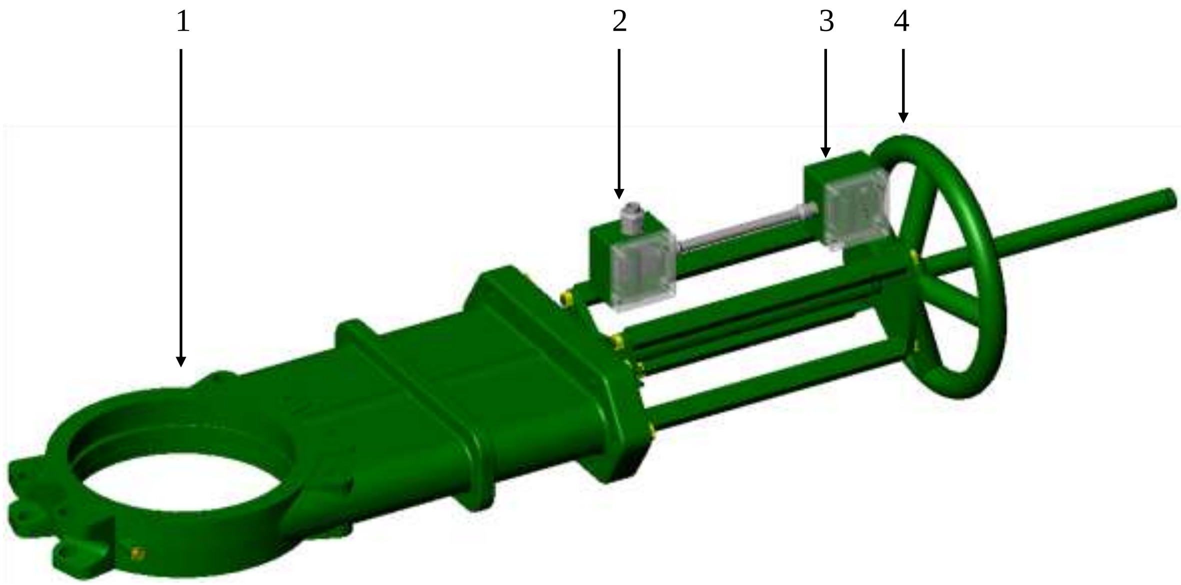
The Shock Absorber is a component which is made of an antistatic PTFE (Polytetrafluorethylene) polymer. The DS must be completely stable and not depend on the Shock Absorber. The Shock Absorber is sent with three spacer rods to prevent damage due to compression of the Shock Absorber during shipment. The three spacer rods (bolt, washer, distance sleeve, and nut) must be removed during the installation. The Shock Absorber is installed between the Isolation Valve and the Rupture Disk. The Shock Absorber is installed on all DS types except the Internal OLTC DS.

NO.	DESCRIPTION
1	Connection for Spacer Rod
2	Flange for Rupture Disk
3	Shock Absorber Bellow (PTFE Material)
4	Reinforcement Ring
5	Flange for Isolation Valve

Figure 43: Shock Absorber

7.5 ISOLATION VALVE

The Isolation Valve is a Bidirectional Knife Gate Valve which is mounted between the Adaptation Piece and Shock Absorber. The purpose of this component is to isolate the TP from the transformer during installation and maintenance phases. The Isolation Valve consists of two position sensors, one “Open Valve” sensor and one “Closed Valve” sensor. A 4-core 1.5mm^2 (14 AWG) cable is connected to the terminals provided in the Isolation Valve Sensor Set (IVSS).



NO.	DESCRIPTION
1	Isolation Valve
2	Isolation Valve Sensor – Fully Closed
3	Isolation Valve Sensor – Fully Open
4	Hand Wheel

Figure 44: Isolation Valve

In order for the Control Box to be in the “In Service” mode, the Isolation Valve must be positioned in the “Valve Open” position. Any time the Isolation Valve is found in the intermediate or closed position (the entire system has just been isolated and unable to perform its duties in case of an internal fault), the Control Box will automatically place itself in the “Out of Service” mode.

7.6 VIBRATION MOUNTS

Four Stainless Steel Vibration Mounts are installed on the DS Base. These Vibration Mounts are found on all transformer DS types.

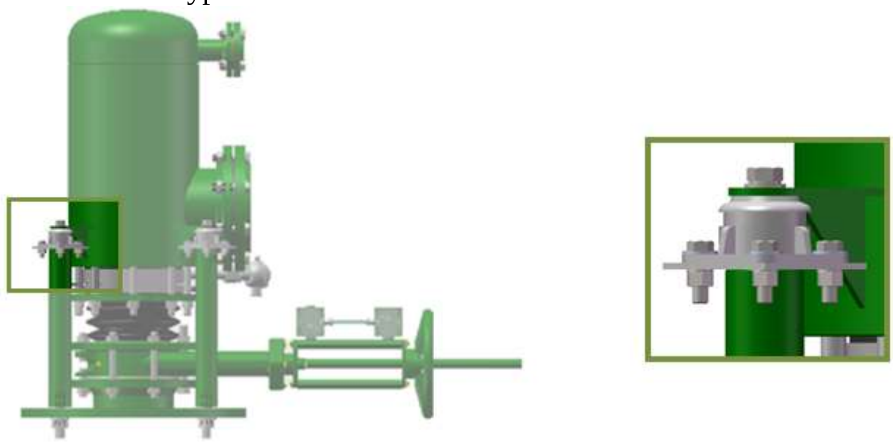


Figure 45: VDS Vibration Mount

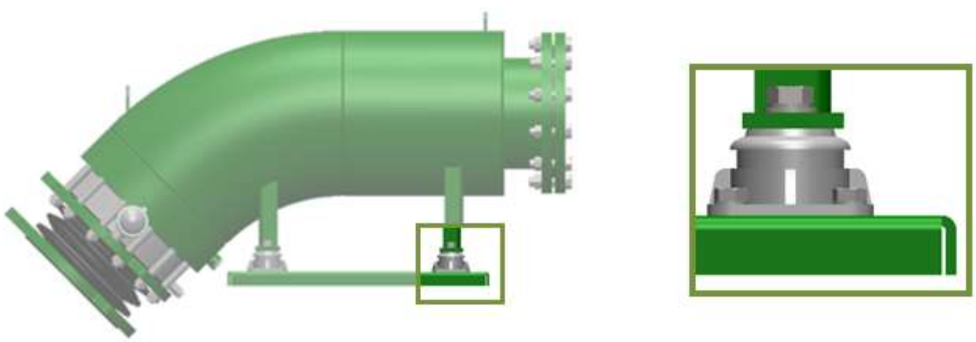


Figure 46: 45°DS Vibration Mount

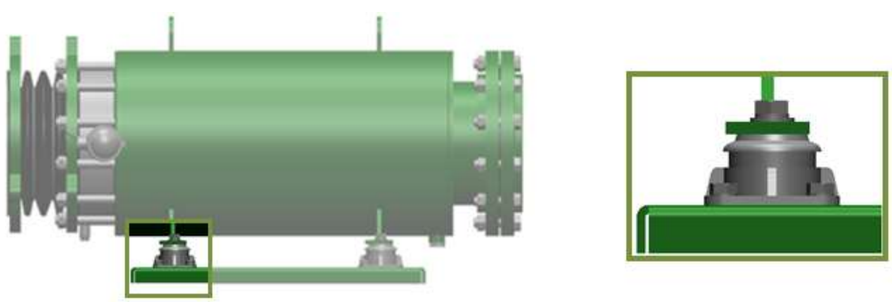
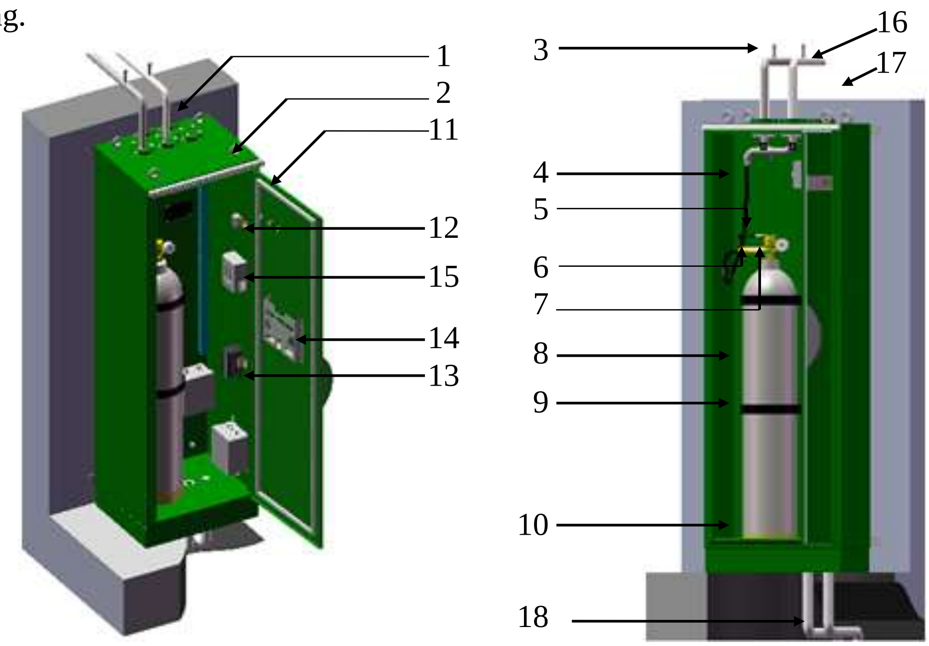


Figure 47: HDS Vibration Mount

7.7 TP CABINET

7.7.1 GENERAL OVERVIEW FOR SINGLE CYLINDER TP CABINET

The TP utilizes the inert gas to evacuate all generated explosive gases and stabilize the transformer to a safe condition once the depressurization process has occurred. The inert gas will be automatically injected into the transformer once and only when the respective signals in the Control Box have been confirmed (TP Standard configuration). The IGIP will be routed from the TP Cabinet to the transformer, OLTCs (if applicable), and OCBs (if applicable). The inert gas is kept in a cylinder with a pressure of up to 200 bar (2900 psi) inside the TP Cabinet and is properly secured under a controlled temperature of 15°C (59°F) and above. The Pressure Reducer inside the TP Cabinet will decrease the inert gas pressure to 1 bar (14.5 psi) in order to smoothly develop the injection process. A Safety Relief Valve will prevent the IGIP from over pressurizing.



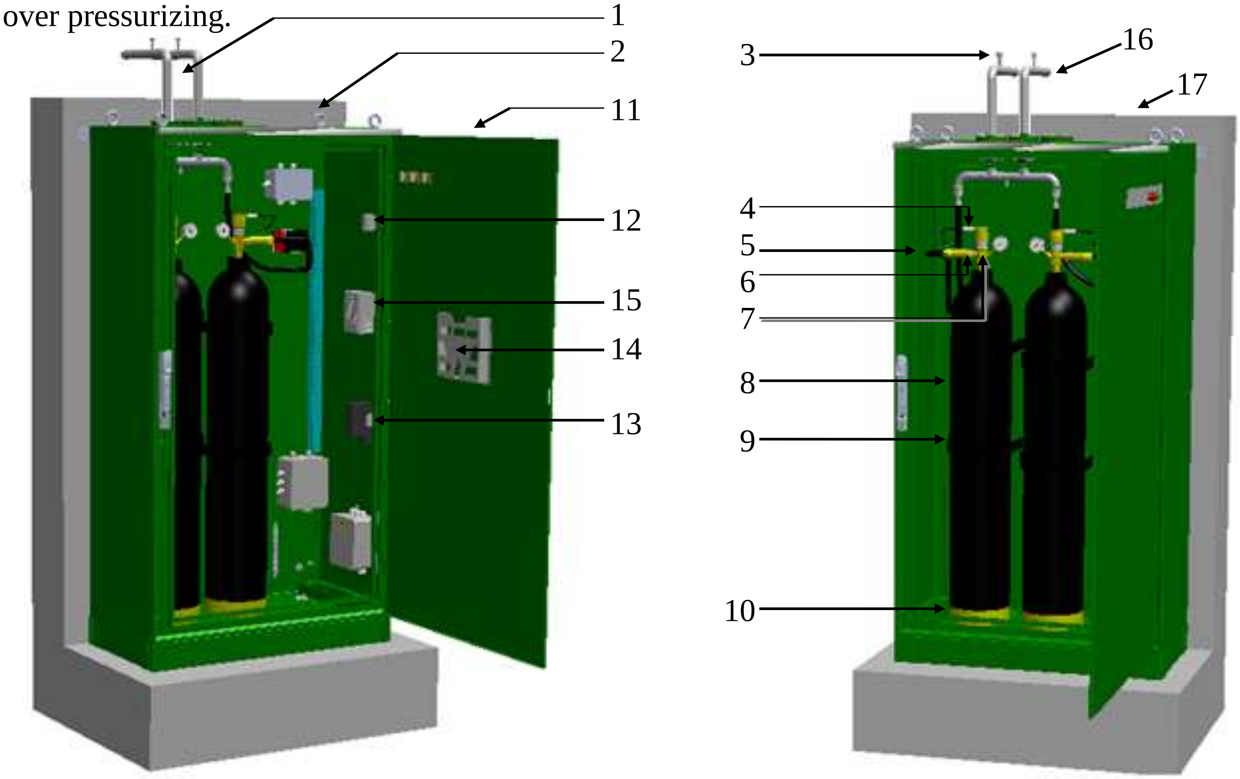
<table>
<tr><th>NO.</th><th colspan="2">DESCRIPTION</th><th>NO.</th><th colspan="2">DESCRIPTION</th></tr>
<tr><td>1</td><td>Double Turret</td><td rowspan="11">Standard TP Scope of Supply</td><td>11</td><td>TP Cabinet</td><td rowspan="4">Standard TP Scope of Supply</td></tr>
<tr><td>2</td><td>Lifting Hooks</td><td>12</td><td>Thermostat</td></tr>
<tr><td>3</td><td>Air Vent</td><td>13</td><td>Heater</td></tr>
<tr><td>4</td><td>Flexible Hose</td><td>14</td><td>Document Holder</td></tr>
<tr><td>5</td><td>Electrical Actuator</td><td>15</td><td>Hygrostat</td><td rowspan="4">Option for Clients</td></tr>
<tr><td>6</td><td>Pressure Reducer</td><td>*</td><td>Interior Cabinet Lighting</td></tr>
<tr><td rowspan="2">7</td><td rowspan="2">Automatic Trigger for Inert Gas Cylinder</td><td>**</td><td>Automatic/Manual Trigger for Inert Gas Cylinder</td></tr>
<tr><td>**</td><td>Manual Trigger for Inert Gas Cylinder</td></tr>
<tr><td>8</td><td>Inert Gas Cylinder</td><td>16</td><td>Inert Gas Injection Piping (IGIP) 1-inch (DN25)</td><td rowspan="3">Client Scope of Supply</td></tr>
<tr><td>9</td><td>Inert Gas Cylinder Supports</td><td>17</td><td>Concrete Wall and Cementation</td></tr>
<tr><td>10</td><td>Inert Gas Cylinder Base Protection</td><td>18</td><td>Conduit for Cabling into the TP Cabinet</td></tr>
<tr><td colspan="6">* Not shown in image. ** This components would replace Item # 7 (Not Shown in image).</td></tr>
</table>

Figure 48: Installed View of Single Cylinder TP Cabinet

No drilling or modifications to the TP Cabinet are allowed.

7.7.2 General Overview for Double Cylinder TP Cabinet

For transformers with a power rating of over 500MVA or more are required to be equipped with the Double Cylinder TP Cabinet. The Double Cylinder TP Cabinet consist of two full inert gas cylinders with a pressure of up to 200 bar (2900psi) respectively. The interior of the enclosure is climate controlled with a temperature of 15°C (59°F) and above. The Pressure Reducer will decrease the inert gas pressure to 1 bar (14.5 psi) in order to smoothly develop the injection process through the Double Cylinder Injection Manifold inside the Double Cylinder TP Cabinet. As with the TP Cabinet, it is equipped with the Safety Relief Valve preventing the IGIP from over pressurizing.



NO.	DESCRIPTION		NO.	DESCRIPTION	
1	Double Turret	Standard TP Scope of Supply	11	TP Cabinet	Standard TP Scope of Supply
2	Lifting Hooks		12	Thermostat	
3	Air Vent		13	Heater	
4	Electrical Actuator***		14	Document Holder	
5	Flexible Hose***		15	Hygrostat	Option for Clients
6	Pressure Reducer***		*	Interior Cabinet Lighting	
			**	Automatic/Manual Trigger for Inert Gas Cylinder	
			**	Manual Trigger for Inert Gas Cylinder	
7	Automatic Trigger for Inert Gas Cylinder***		16	Inert Gas Injection Piping (IGIP) 1-inch (DN25)	Client Scope of Supply
8	Inert Gas Cylinder		17	Concrete Wall and Cementation	
9	Inert Gas Cylinder Support***		*	Conduit for Cabling into the TP Cabinet	
10	Inert Gas Cylinder Base Protection***				

* Not shown in image. ** This components would replace Item # 7 (Not Shown in image).
*** Will consist of the same components for the second Inert Gas Cylinder.

Figure 49: Installed View of Double Cylinder TP Cabinet

No drilling or modifications to the TP Cabinet are allowed.

7.7.3 TP CABINET

The TP Cabinet has to be secured from its base to a concrete base or structural support at least 150 mm (6-inches) from the floor to prevent any possible water damage. The concrete foundation must be designed to withstand approximately 222 kg (490 lbs). The TP Cabinet must also be secured to the transformer firewall or concrete wall. The TP Cabinet has to be placed at least 5 meters (16.4 ft) away from the transformer, unless installed behind the transformer firewall. All cables are connected inside the respective connection boxes using assigned connectors at the bottom of the TP Cabinet.

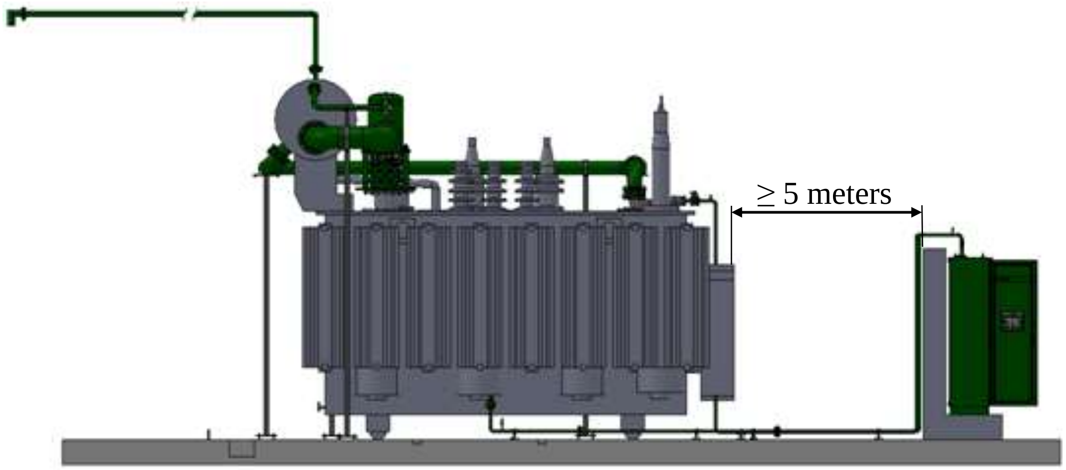


Figure 50: TP Cabinet Location without Firewall

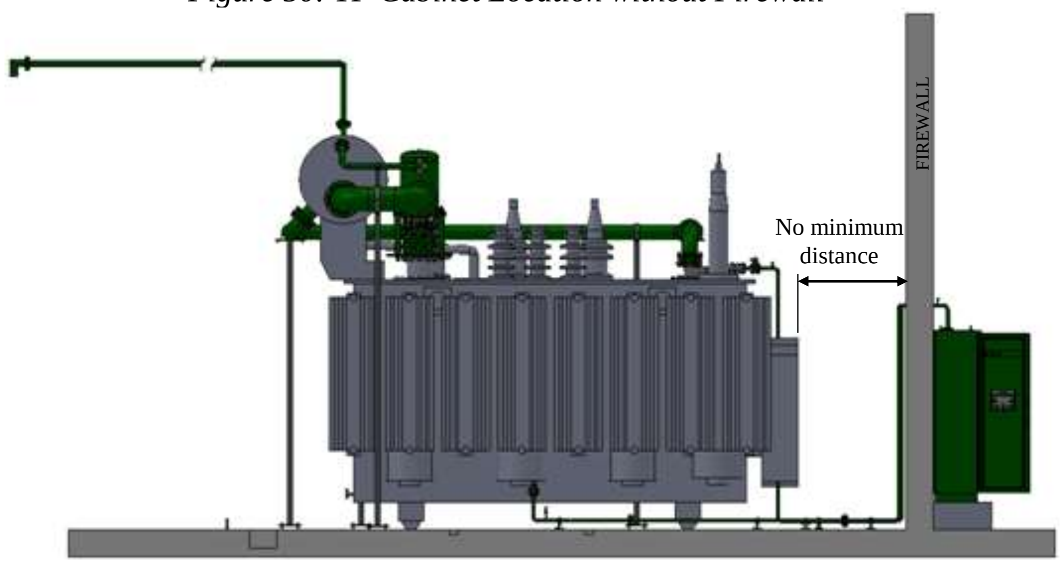


Figure 51: TP Cabinet Location with Firewall

7.7.3.1 TP Cabinet and Air Vents

The TP Cabinet is designed as per the TP arrangement type. The TP Cabinet top section and the respective IGIP Connections will be prepared for the injection of inert gas to the transformer. One line will be utilized for the injection of inert gas into the transformer and the second line will be for the OLTCs (if applicable) and OCBs (if applicable). An Air Vent is to be installed on the IGIP (both IGIP if applies) located above the TP Cabinet. If the OLTC/OCB IGIP is routed higher than the Air Vents found above the TP Cabinet then additional Air Vents will need to be installed at the IGIP highest location. The Air Vent is part of the TP scope of supply.

7.7.3.2 TP Cabinet Manifold

The TP Cabinet Manifold will disproportionately divide the flow of inert gas into the IGIP lines depending on the volume of the compartments. A Safety Relief Valve (SRV), calibrated at 5 bar, is installed on the Manifold to prevent over pressurizing. The Manifold will be labeled with letters “T” and “A”; “T” indicating the IGIP connection for the transformer and “A” indicating the IGIP connection for the OLTC/OCB.

(a) TP system with a TP configuration *(b) TP system with a TPA, TPB, or TPAB configuration*

Figure 52: Manifold for Single Bottle TP Cabinet

7.7.3.3 TP Cabinet with Single IGIP Connection

The TP Cabinet with Single IGIP Connection consists of one DN 25 flange and two blind flanges. The IGIP is connected from the respective TP Cabinet connection to the transformer. This type of TP Cabinet is only supplied when the OLTC and OCB are not available in the TP configuration.

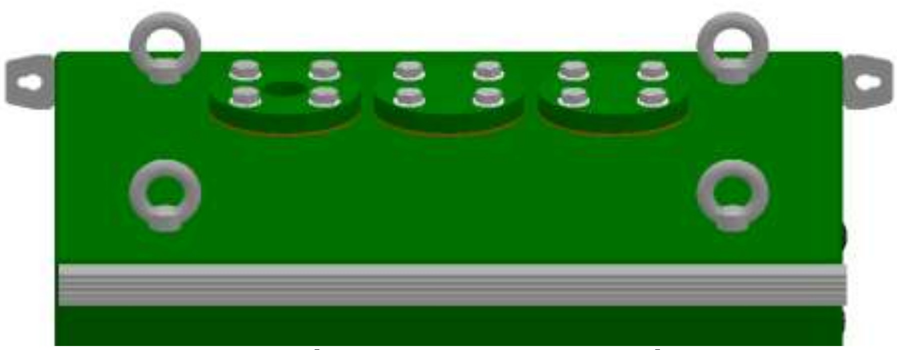


Figure 53: Single IGIP Connection TP Cabinet

7.7.3.4 TP Cabinet with Double IGIP Connections

The TP Cabinet with Double TP Connections consists of two DN 25 flanges and one blind flange. The IGIP that is routed to the transformer will be connected to the first flange found on the left (looking from the front of the TP Cabinet). The IGIP that is routed to the OLTC and/or OCB will be connected to the second flange found on the right (looking from the front of the TP Cabinet). The IGIP for the OLTC and/or OCB will be shared from this IGIP connection; which would inject inert gas into the OLTC and OCB if applicable.

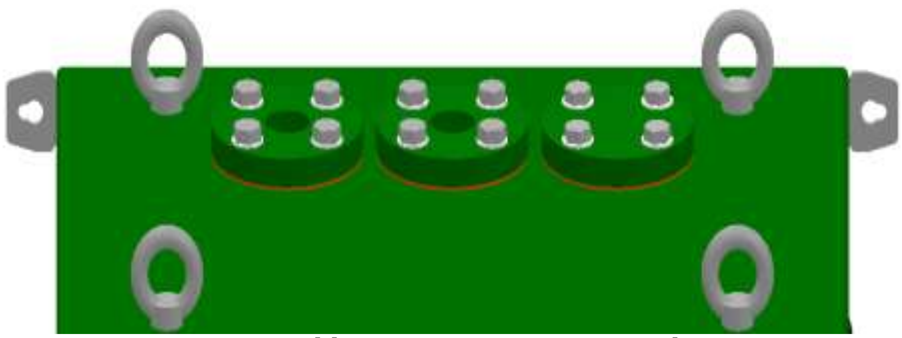


Figure 54: Double IGIP Connection TP Cabinet

7.7.3.5 Inert Gas Cylinder

The Inert Gas Cylinder has a volume of 50 L with an operational pressure from 150 bar (2,175 psi) to 250bar (3,626 psi). Inert Gas is filled at a 200 bar (2900 psi) pressure with a protection head connection for the Inert Gas Injection Kit. An Electrical Pressure Gauge (Manometer) of low level pressure (140 bar / 2031 psi) forms part of its assembly.

7.7.3.6 Thermostat and Heater

The temperature inside the TP Cabinet is controlled by a thermostat which is found inside the TP Cabinet. The Inert Gas Cylinder is stabilized above 15°C (59°F). The thermostat and heater are part of the TP Scope of Supply. The nominal voltage for the power supply which feed the Cabinet Heater and Thermostat is 110- 240 AC.

Figure 55(a)
TP Cabinet Thermostat

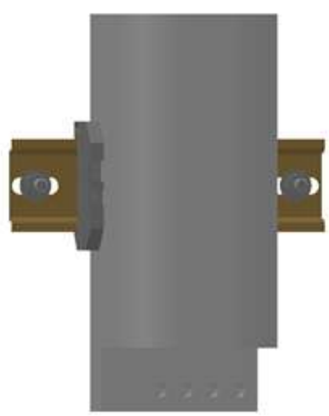


Figure 55(b)
TP Cabinet Heater

Figure 55: TP Cabinet Thermostat and Heater

7.7.3.7 Inert Gas Injection Kit

This mechanical device will generate the activation of inert gas once a spark is initiated by the Electrical Actuator. Automatic activation will occur when the TP logic has been confirmed.

a) Electrical Actuator

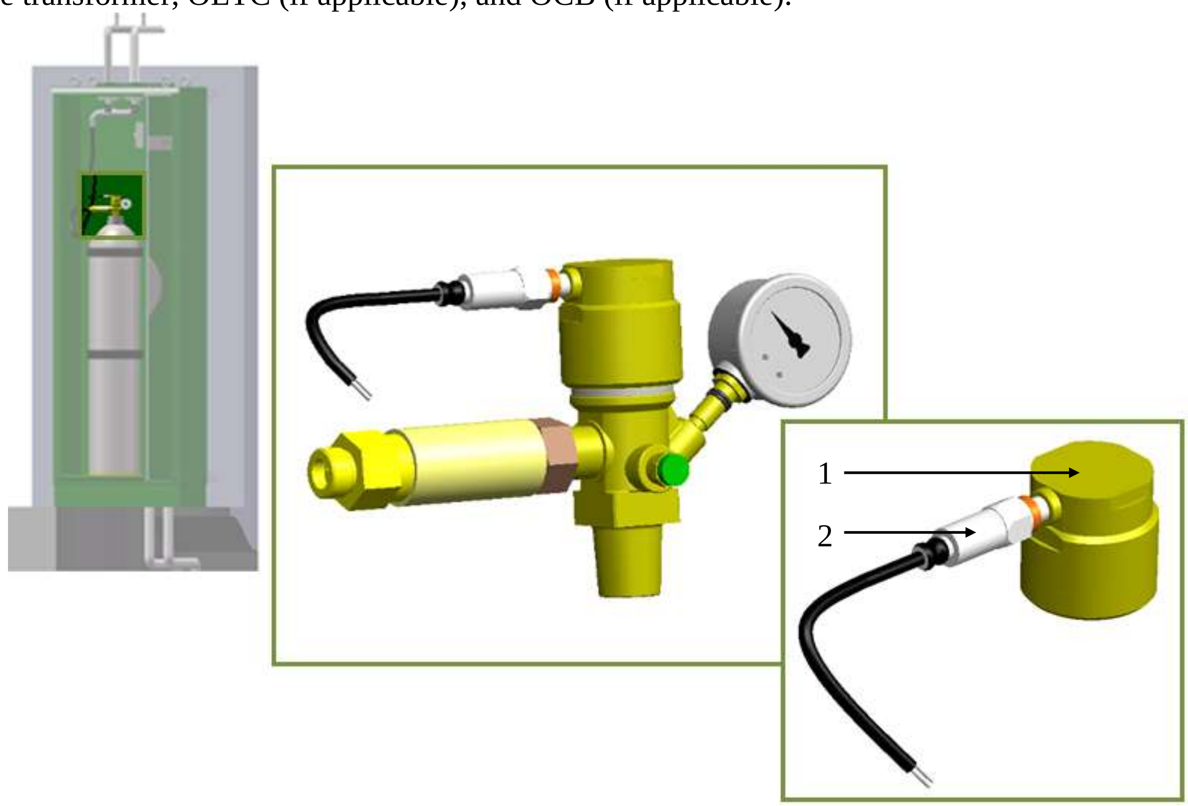
The Electrical Actuator is a pyrotechnic device which is activated by a short circuit controlled by the Control Box logic. Its activation is done once several states are confirmed in the Control Box. Once the Electrical Actuator is activated, it has to be replaced.

The Electrical Actuator must be installed for the first time by the Commissioning Engineer during the TP Commissioning. During transformer normal operation and/or maintenance, the maintenance personnel must review the instructions given in the document "Operation, Maintenance, and Periodical Tests" in order to properly replace the Electrical Actuator.

7.7.3.8 Trigger for Inert Gas Cylinder

a) Automatic Trigger for Inert Gas Cylinder (Standard)

For automatic inert gas injection, two simultaneous signals are given to the Control Box so that the IGIS can be started automatically. The Automatic Trigger for Inert Gas Cylinder (standard TP Scope of Supply) will allow the automatic injection of inert gas smoothly into the bottom of the transformer, OLTC (if applicable), and OCB (if applicable).



No.	Item Description
1	Automatic Trigger for Inert Gas Cylinder
2	Electrical Actuator

Figure 56: Automatic Trigger for Inert Gas Cylinder

7.8 OIL-GAS SEPARATION TANK

7.8.1 OGST STANDARD CONFIGURATION

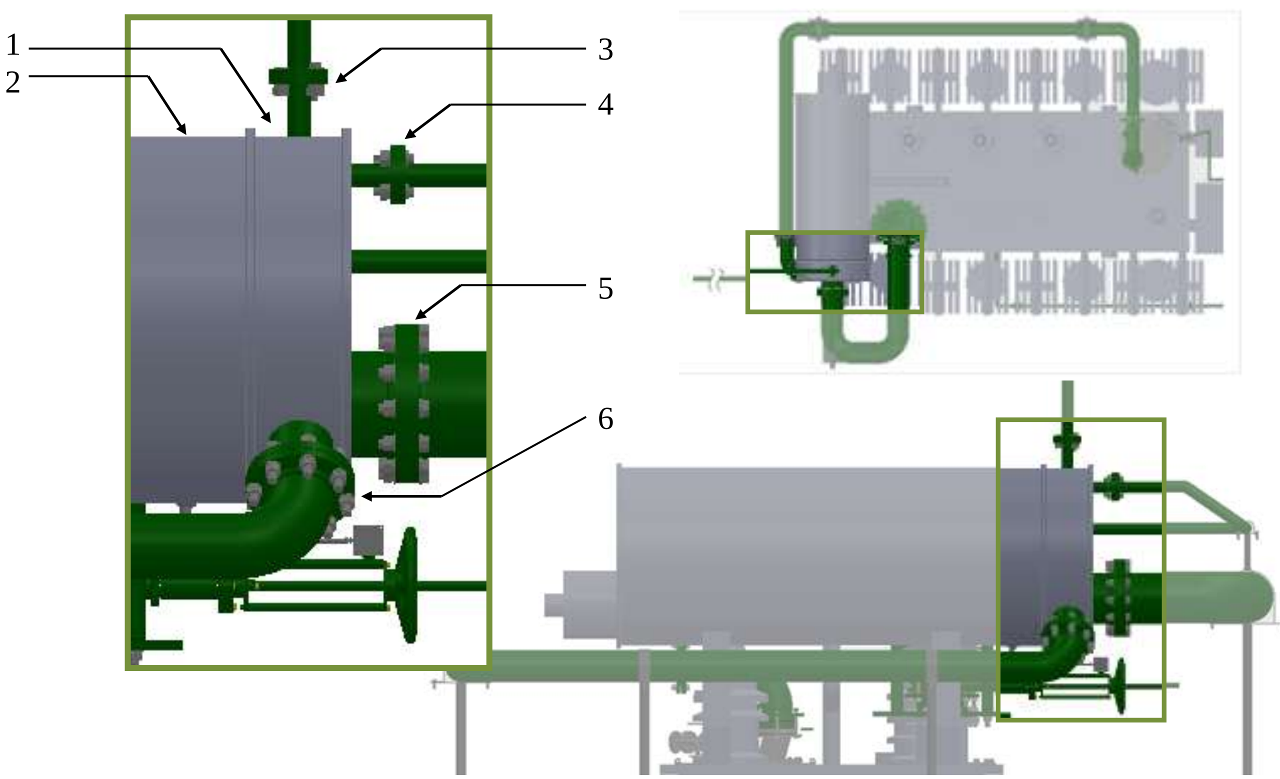
The location of the OGST shall be according to the location of the Transformer DS, selecting the shortest route for the ODP. The OGST cannot be shared with other TP Systems.

7.8.1.1 Slice Oil-Gas Separation Tank Development

The SOGST should have a minimum volume of 0.5 m^3 (132 gallons) and be part of the transformer conservator tank. For the SOGST development it must be considered the following details:

- The SOGST has a connection for the ODP (ODP size correspond to the transformer DS size) which should be located at the lowest point;
- A flange must be installed for the adaptation of the ODP;
- A DN 25 (1-inch) should be installed for the GEP (unless 45°DS is installed);
- A DN 50 (2-inch) connection at the top of the SOGST should be prepared for the installation of the EGEP;

The transformer manufacturer must request confirmation and approval from Project Department for the SOGST development before the design is sent for manufacturing. The amount of SOGST connections may vary according to TP design.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	Slice OGST	4	GEP Connection
2	Transformer Conservator Tank	5	ODP Connection – Transformer DS
3	Explosive Gas Evacuation Pipe Connection	6	ODP Connection – OLTC DS

Figure 57: SOGST

7.8.2 ALTERNATE OGST FROM STANDARD CONFIGURATION

If it is not possible to install the SOGST, there are alternatives which will maintain the TP specifications. These alternatives refer to a change in design of the OGST. The different type of OGST can either be included in the TP scope of supply or provided by the client. The OGST cannot be shared with other TP Systems.

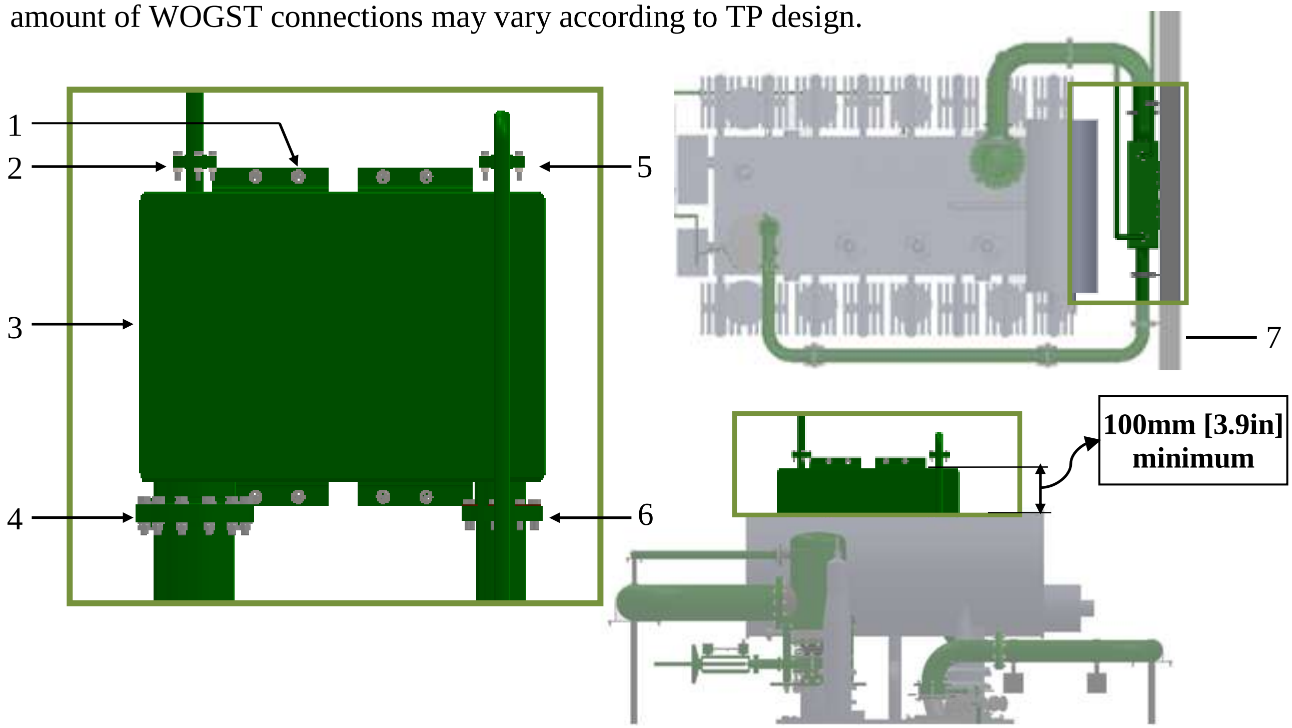
7.8.2.1 Wall mounted Oil-Gas Separation Tank

The WOGST should have a minimum volume of 0.5 m^3 (132 gallons) and the size of the ODP connection should be as per the transformer DS size.

For the WOGST development it must be considered the following details:

- At the bottom of the WOGST a connection for the ODP should be located;
- A flange should be installed for the adaptation of the ODP;
- The top of the WOGST a DN 25 (1-inch) should be installed for the GEP (unless 45°DS is installed);
- A flange should be installed for the adaptation of the GEP;
- The WOGST should have a DN 50 (2-inch) connection at the top for the installation of the EGEP;
- A flange should be installed for the adaptation of the EGEP.

The WOGST should be securely mounted to the transformer firewall with the top of the OGST at least 100 mm (3.9-inches) above the highest point of the transformer conservator tank. The amount of WOGST connections may vary according to TP design.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	WOGST support	5	GEP Connection
2	EGEP Connection	6	ODP Connection – OLTC DS
3	WOGST	7	Firewall
4	ODP Connection – Transformer DS		

Figure 58: WOGST mounted to Firewall

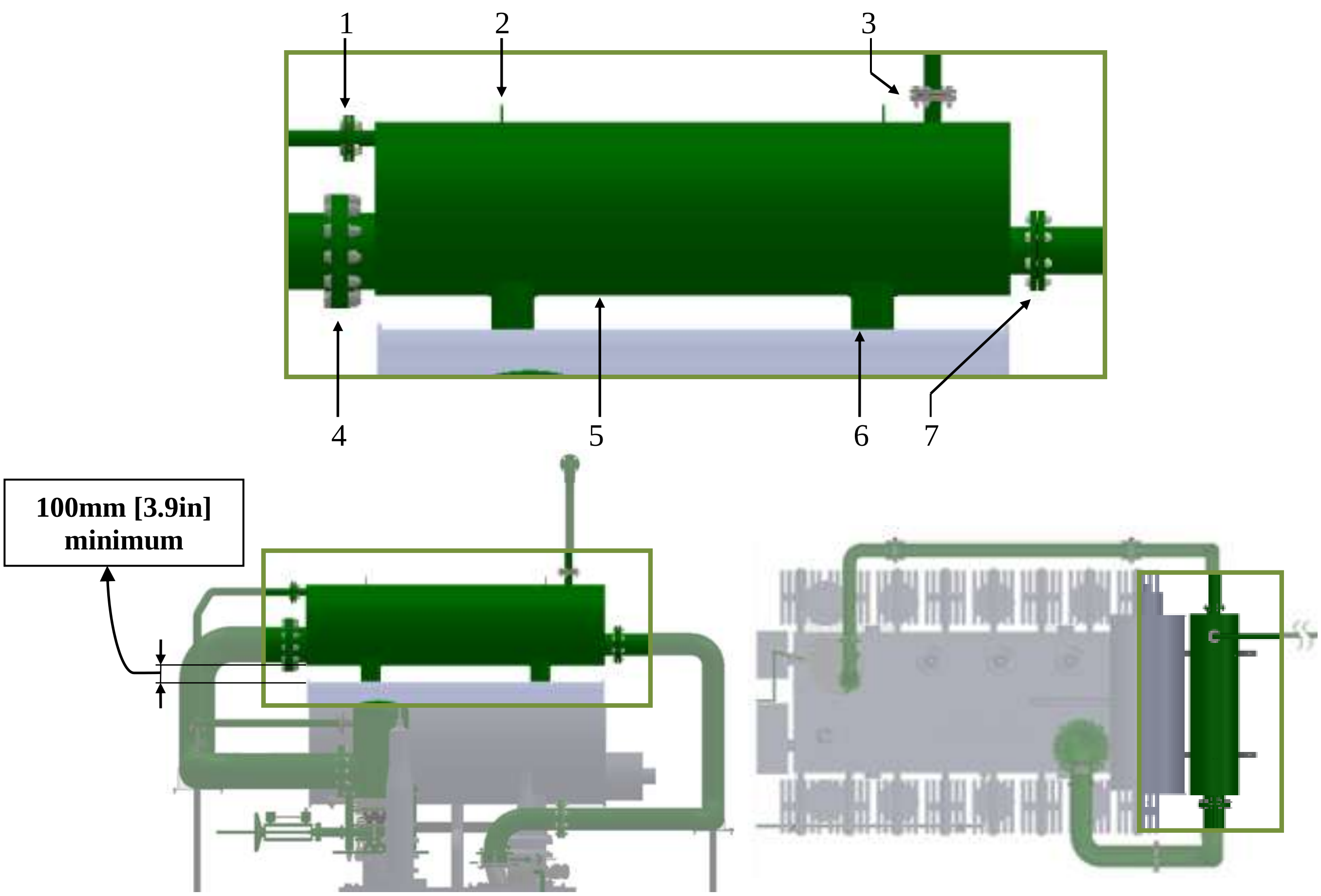
7.8.2.2 Elevated Oil-Gas Separation Tank

The EOGST is a cylindrical compartment designed as per the transformer conservator design. The EOGST should have a minimum volume of 0.5 m^3 (132 gallons).

For the EOGST development it must be considered the following details:

- At the lowest point of the EOGST a connection for the ODP should be located;
- A flange should be installed for the adaptation of the ODP;
- The top or side of the EOGST a DN 25 (1-inch) connection should be installed for the GEP (unless 45°DS is installed);
- A flange should be installed for the adaptation of the GEP;
- The EOGST should have a DN 50 (2-inch) connection at the top for the installation of the EGEP;
- A flange should be installed for the adaptation of the EGEP.

The EOGST should be securely mounted and supported to the transformer or ground and with the bottom of the OGST at least 100 mm (3.9-inches) above the highest point of the transformer conservator tank. The amounts of EOGST connections may vary according to TP design.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	Gas Evacuation Pipe Connection	5	Elevated Oil-Gas Separation Tank
2	Lifting Hooks	6	Support
3	Explosive Gas Evacuation Pipe Connection	7	Oil Drain Pipe Connection – OLTC DS
4	Oil Drain Pipe Connection – Transformer DS		

Figure 59: EOGST for a TPA configuration

7.9 EXPLOSIVE GAS EVACUATION SET

The Explosive Gas Evacuation Set (EGES) is made up of the Explosive Gas Evacuation Pipe (EGEP) and Air Isolation Shutter (AIS). After the TP activation and inert gas injection into the transformer, all explosive gases will be routed safely away from the transformer and equipment in the surrounding.

7.9.1 AIR ISOLATION SHUTTER

The AIS is a check valve which is used to evacuate all the explosive gases collected after the activation of the TP. The AIS is a retention valve that does not allow air to enter the piping but facilitates the outlet of the explosive gases from the system. The AIS is also to be located at least 5 meters (16.4 ft) from the ground and 100 mm (3.9-inch) above the OGST. Please refer to Section 9.3 for more details.

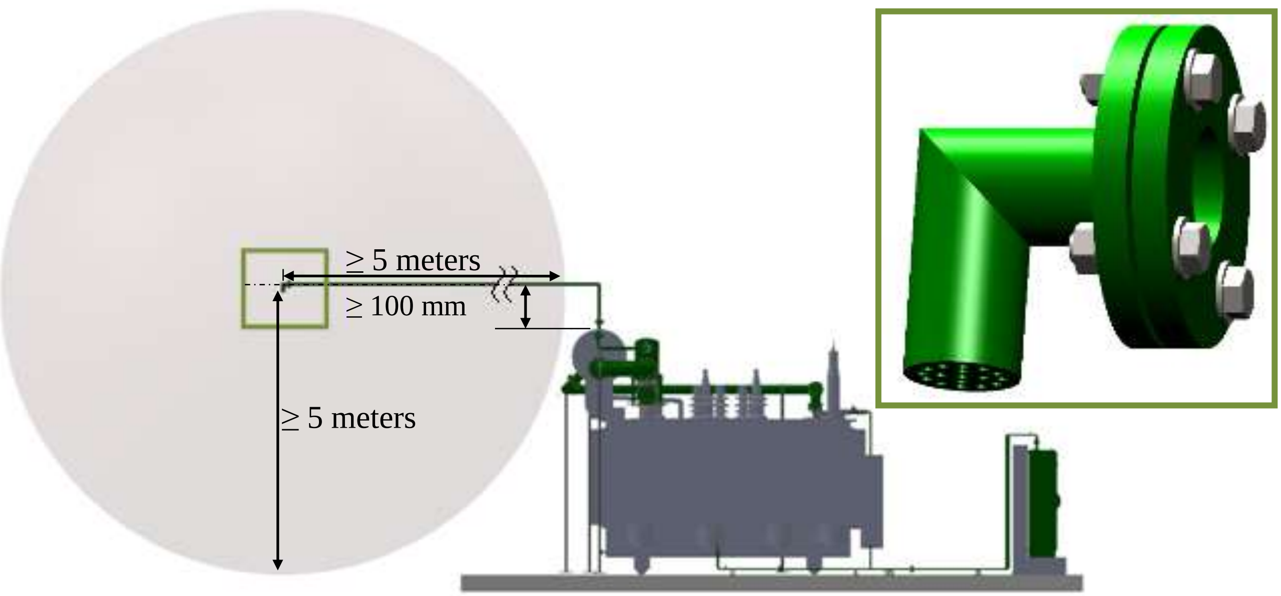


Figure 60: Air Isolation Shutter

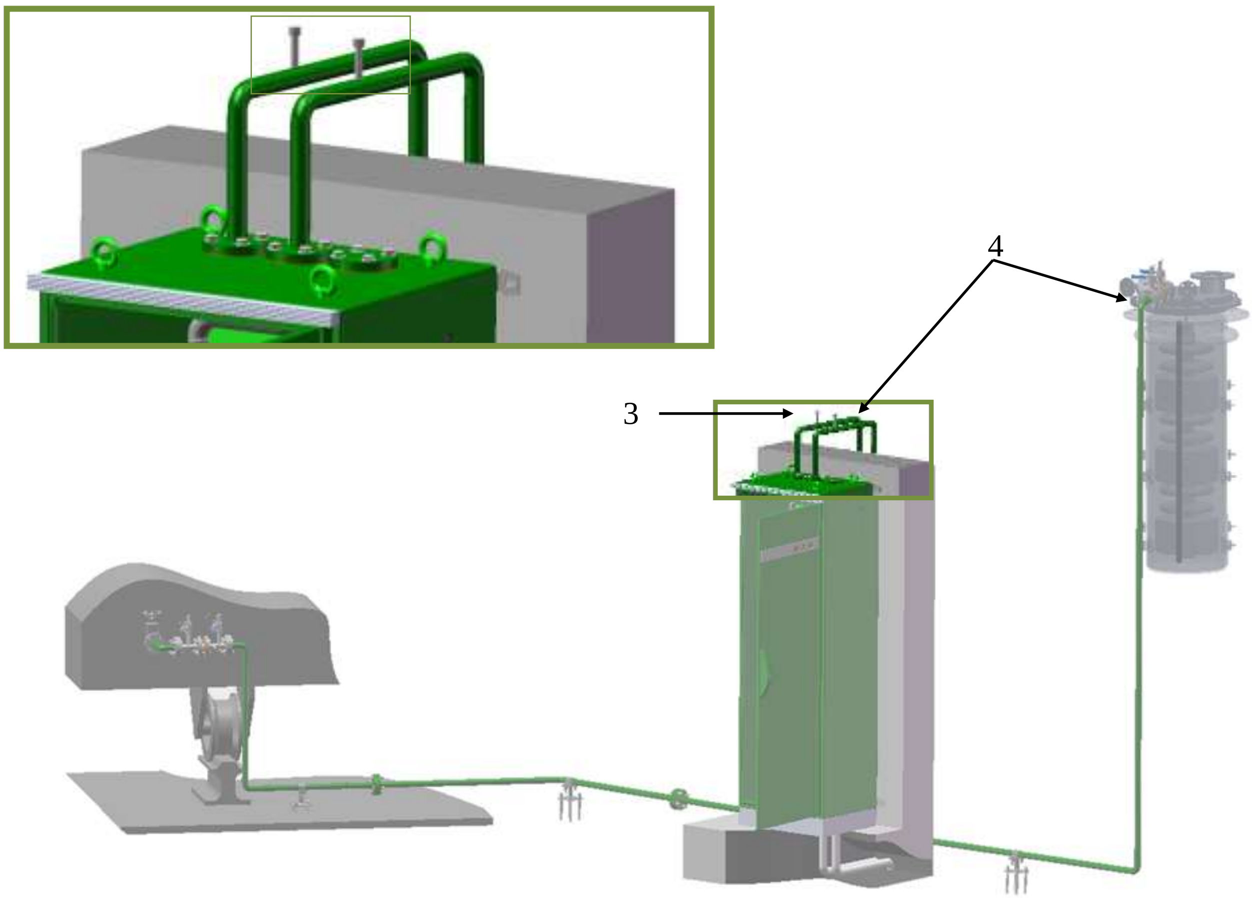
The AIS is to be located at least 5 meters (16.4 ft) from the ground, transformer, and any surrounding equipment. The AIS is also to be located at least 100 mm (3.9 inches) above the highest point of the OGST.

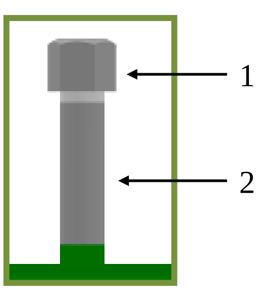
7.10 AIR VENT

The Air Vent, which consists of a nipple and Stainless Steel sealing nut, will allow removing the trapped air inside the IGIP. The Air Vent is part of the TP scope of supply.

The Air Vent locations should be as follow:

- Above the TP Cabinet on the Transformer IGIP.
- Above the TP Cabinet on the OLTC/OCB IGIP.
- At the highest point on the Transformer IGIP (if higher than Air Vent above TP Cabinet).
- At the highest point on the OLTC IGIP (if higher than Air Vent above TP Cabinet).
- At the highest point on the OCB IGIP (if higher than Air Vent above TP Cabinet).





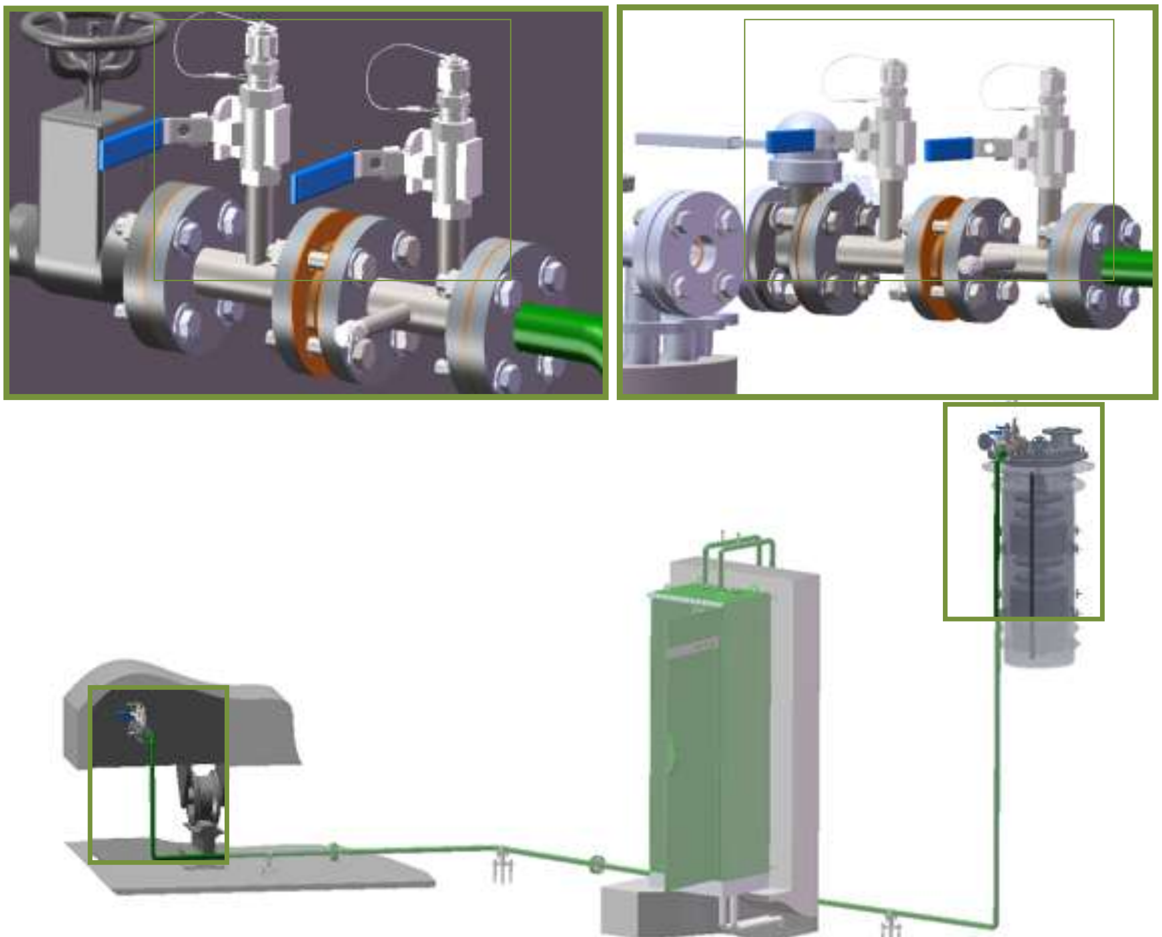
NO.	DESCRIPTION
1	Sealing Nut
2	Double Nipple, ¼” NPT
3	Transformer IGIP
4	OLTC IGIP

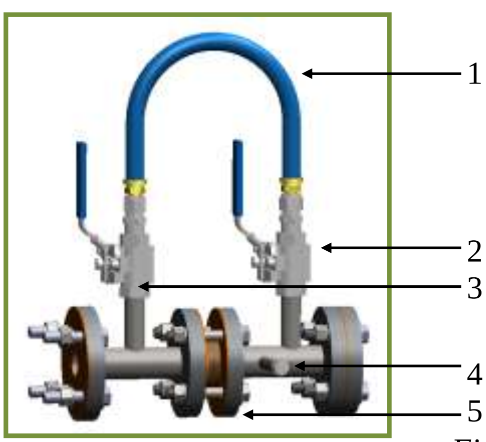
Figure 61: Air Vent location on the IGIP

7.11 NRV SET FOR IGIP

7.11.1 MANUAL BALL VALVES

Two manual valves will be supplied in order to fill the entire length of the IGIP with transformer oil. This will ensure that no air will be injected into the transformer during injection of the inert gas. A flexible hose will be supplied in order to connect the two manual valves together bypassing the Non-Return valve, allowing the IGIP to be filled with oil. The same design that is shown in figure below for the OLTC will apply of the OCB. The manual valves, Non-Return Valve, and Safety Relief Valve will all be supplied, welded, and assembled together as part of the TP Scope of Supply.



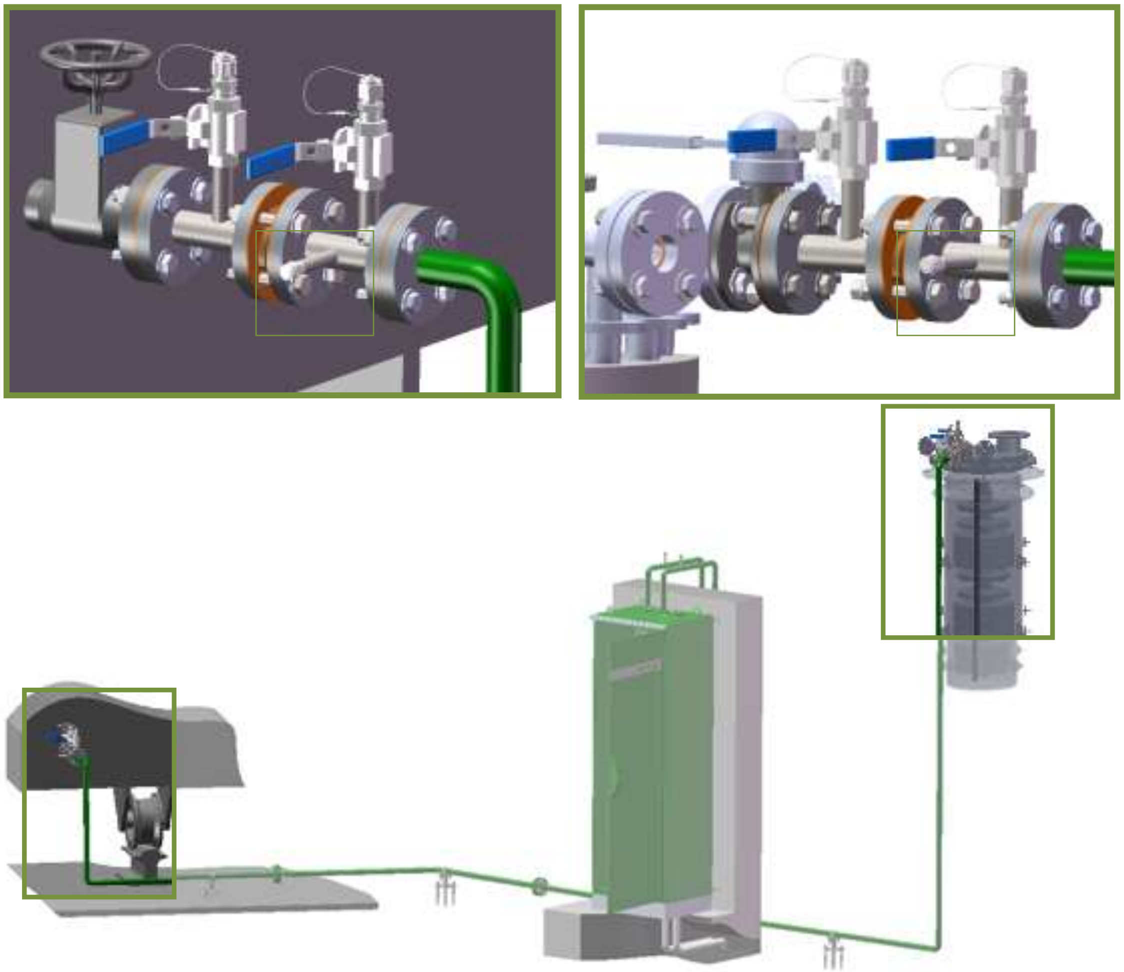


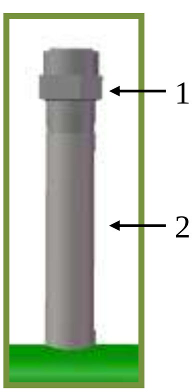
NO.	DESCRIPTION
1	Flexible Hose to connect manual valves
2	Manual Valve
3	Manual Valve next to Transformer, OLTC, or OCB
4	Safety Relief Valve
5	Non-Return Valve

Figure 62: Manual Valves

7.11.2 SAFETY RELIEF VALVE

The Safety Relief Valve (SRV) prevents the over pressurizing of the IGIP. The SRV has an opening set point of 3.5 bars (50 psi). A galvanized or stainless steel socket for SRV is provided, which should be welded to the IGIP. The SRV is then torqued onto the Electroplated Socket. The Safety Relief Valve is supplied, welded, and assembled to the NRV Set for the IGIP.



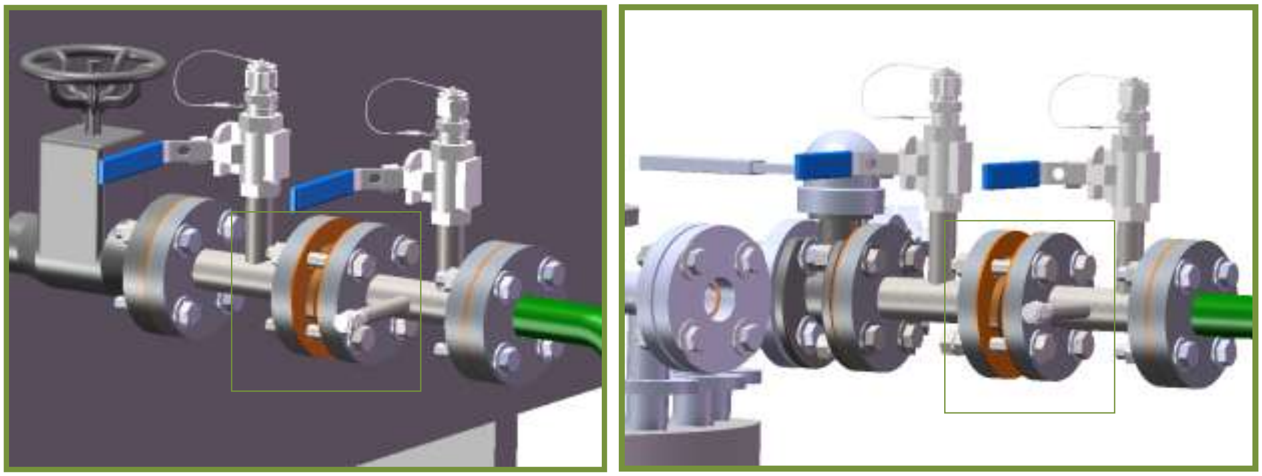


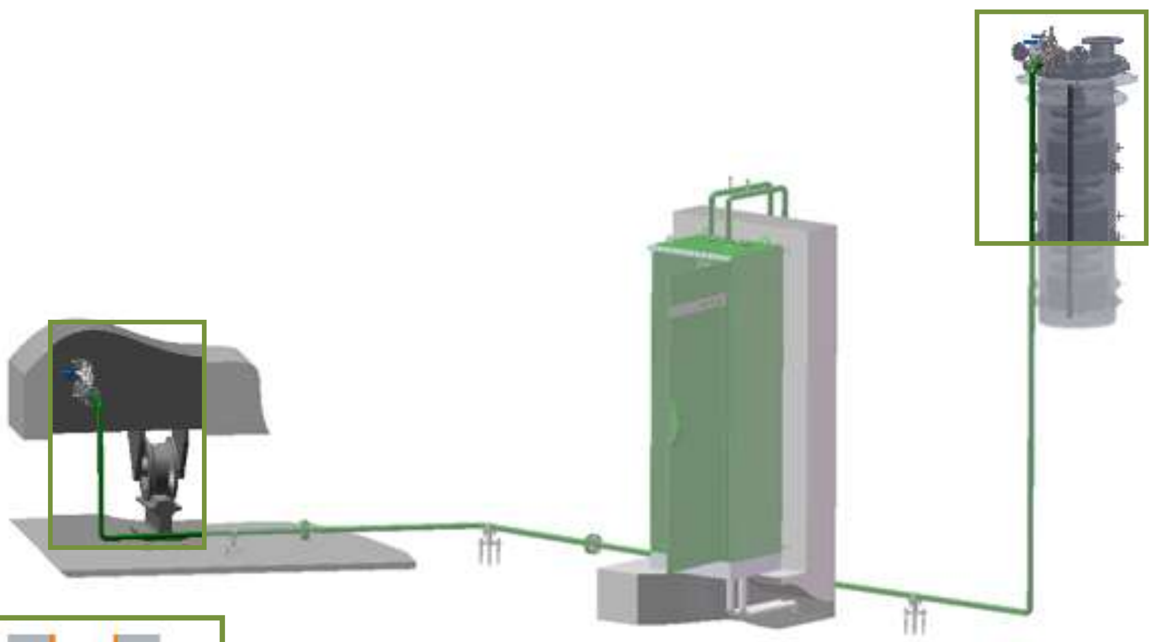
NO.	DESCRIPTION
1	Safety Relief Valve
2	Socket for Safety Relief Valve

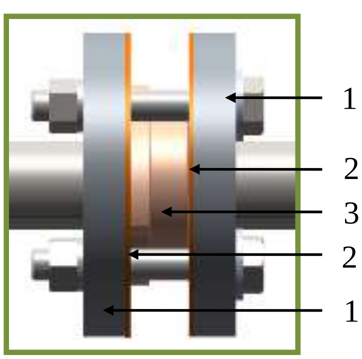
Figure 63: Safety Relief Valve located on the IGIP

7.11.3 NON-RETURN VALVE

The Non-Return Valve (NRV) prevents the transformer from draining if the IGIP was to be broken or accidently damaged. The NRV is DN 25 (1-inch) to be placed between two flanges on the IGIP. The NRV flange is supplied, welded, and assembled to the NRV Set for IGIP. The same design that is shown in figure below for the OLTC will apply of the OCB. The NRV is part of the TP scope of supply.





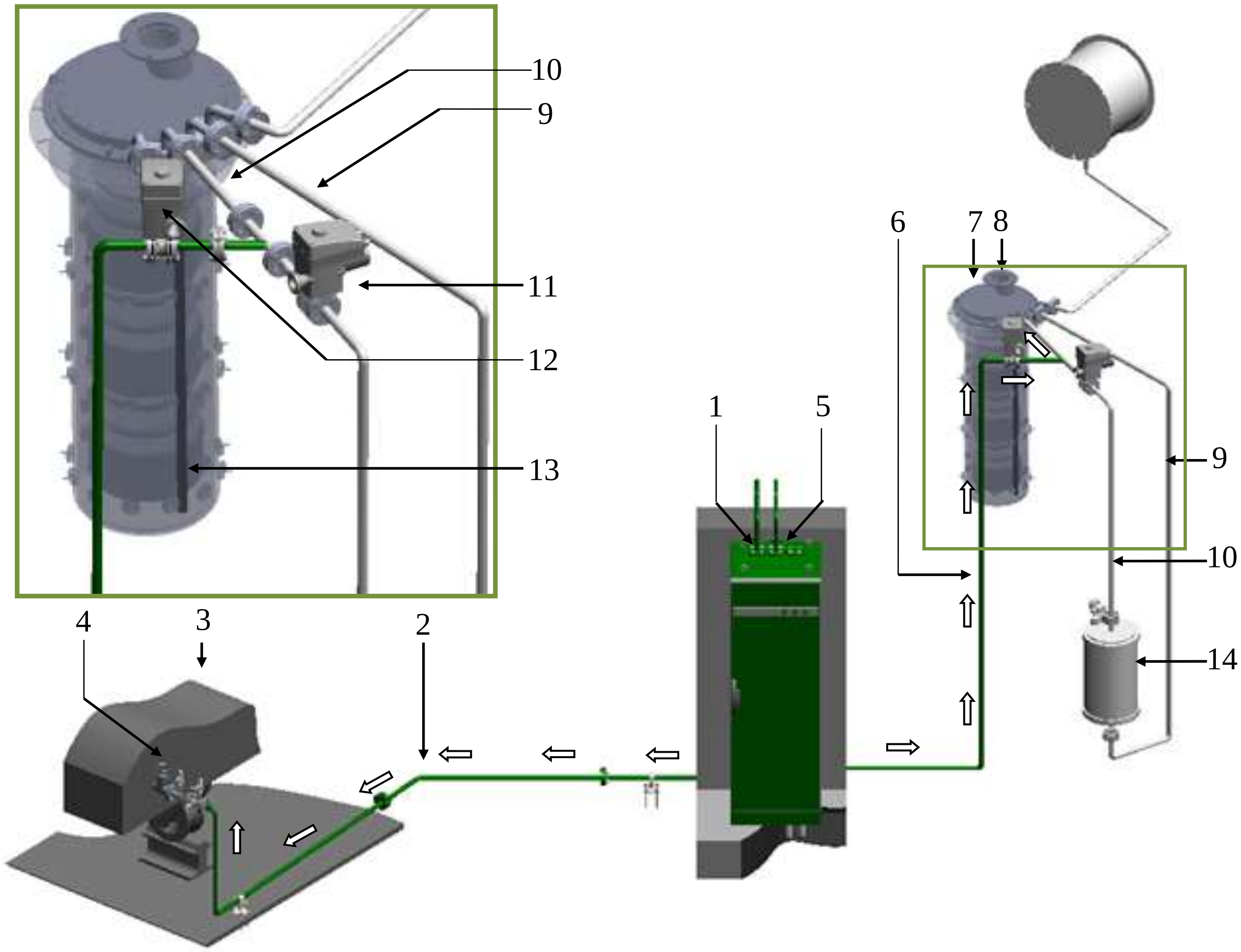


NO.	DESCRIPTION
1	IGIP Flange
2	Nebar Gasket
3	Non-Return Valve

Figure 64: Non-Return Valve located on the IGIP

7.12 ADAPTATION TO OIL FILTRATION UNIT

Inert gas will be injected through the IGIP to ensure a safe state is kept inside the OLTC/OCB. The Oil Filtration Unit (OFU) should be completely isolated from the OLTC/OCB and TP during injection of inert gas, in which two Electro Valves are utilized for this same purpose.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	TP Cabinet Transformer IGIP connection	8	DN150 (6 in) Flange for OLTC DS
2	Transformer IGIP	9	OFU inlet pipe coming from OLTC
3	Transformer	10	OFU outlet pipe directed to OLTC
4	Transformer Drain Valve	11	Electro Valve S2
5	TP Cabinet OLTC IGIP connection	12	Electro Valve S1
6	OLTC IGIP connected with OFU outlet piping	13	OLTC IGIP to the bottom of the OLTC
7	OLTC	14	OFU

Figure 65: IGIP Connection to OLTC with OFU

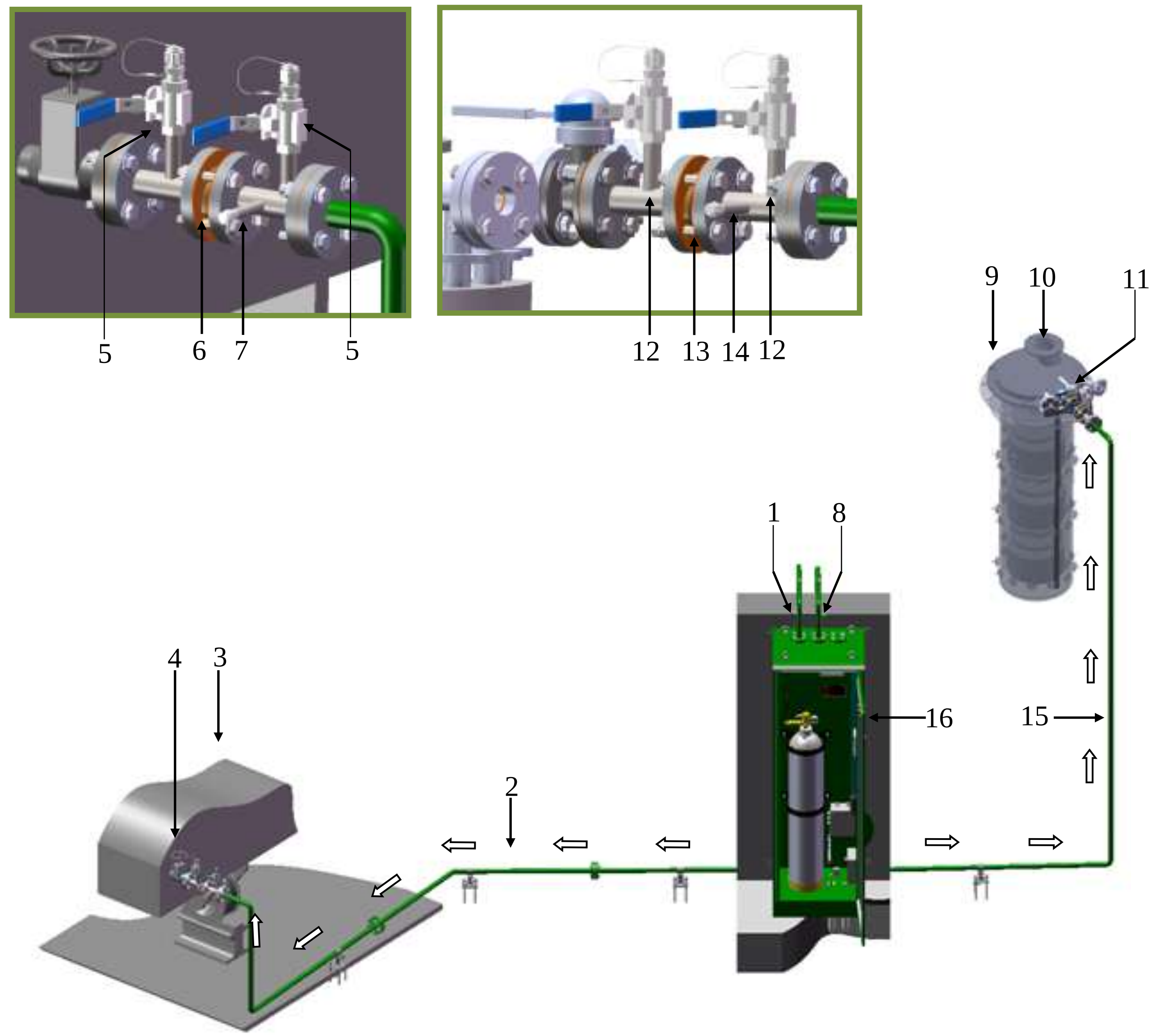
- The Electro Valve S1, located on the OLTC IGIP, is normally closed to prevent transformer and OLTC oil from mixing when the OFU pump is working. In case of inert gas activation, the Electro Valve S1 is opened.
- The Electro Valve S2, located near the OFU outlet is normally open and will close only in the case of inert gas injection which is done in order to prevent pressurizing the OFU.

The same design concept that is shown in Figure 65 will apply on the OCB.

7.13 IGIP CONNECTION

For all types of OLTCs/OCBs the IGIP can be connected with the following interfaces:

- Manual Ball Valve with a DN25 (1-inch) connecting flange.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	TP Cabinet Transformer IGIP connection	9	OLTC
2	Transformer IGIP	10	DN150 (6 in) Flange for OLTC DS
3	Transformer	11	OLTC IGIP connection
4	Transformer Drain Valve	12	OLTC IGIP Manual Valves
5	Transformer IGIP Manual Valves	13	OLTC IGIP Non-Return Valve
6	Transformer IGIP Non-Return Valve	14	OLTC IGIP Safety Relief Valve
7	Transformer IGIP Safety Relief Valve	15	OLTC IGIP
8	TP Cabinet OLTC IGIP connection	16	TP Cabinet

Figure 66: IGIP Connection to OLTC without OFU

The same design concept that is shown in Figure 66 will apply on the OCB.

7.13.1 ELECTRO VALVE

The Electro Valve is to allow or block the flow of a fluid or gas. The Electro Valve operating time (0° - 90°) is 6 seconds. In stand-by mode the valve is found in the closed position, and in the case of activation, the valve will be automatically situated in the open position. The Electro Valve may be used in several different scenarios such as the followings:

- Installed on the GEP for a HDS configuration which would allow the evacuation of explosive gases from transformer after activation. Refer to Section 9.2.2 for more details.

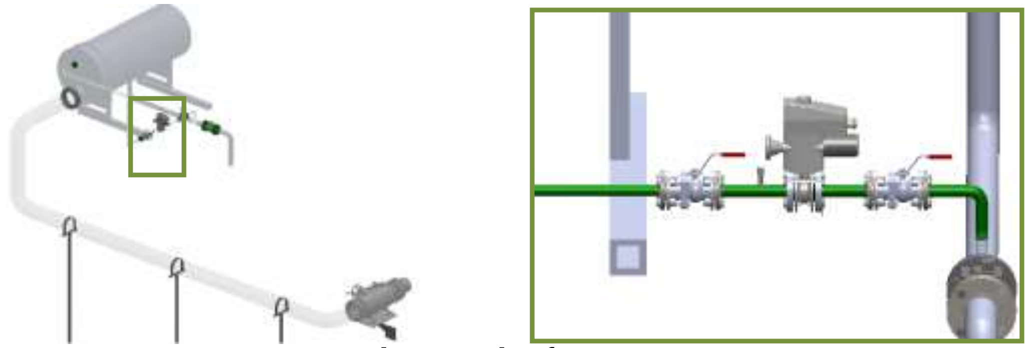


Figure 67: Electro Valve for HDS GEP

- Installed on the OFU setup (isolate the OFU automatically). Refer to Section 7.13 for more details.

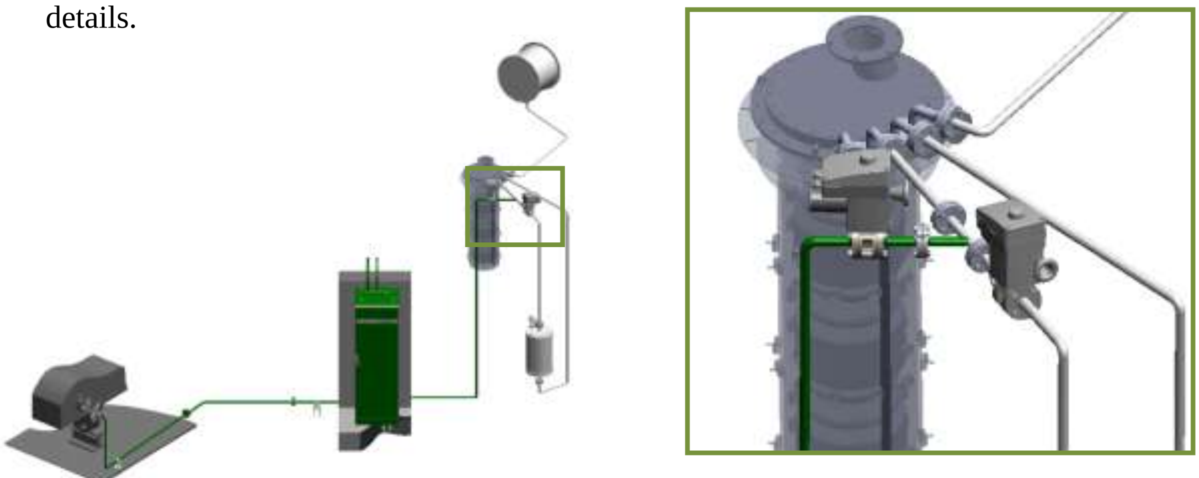


Figure 68: Electro Valve for OLTC OFU

- (Option) Installed on the IGIP to allow inert gas injection into the transformer, OLTC, and OCB in the case of activation.

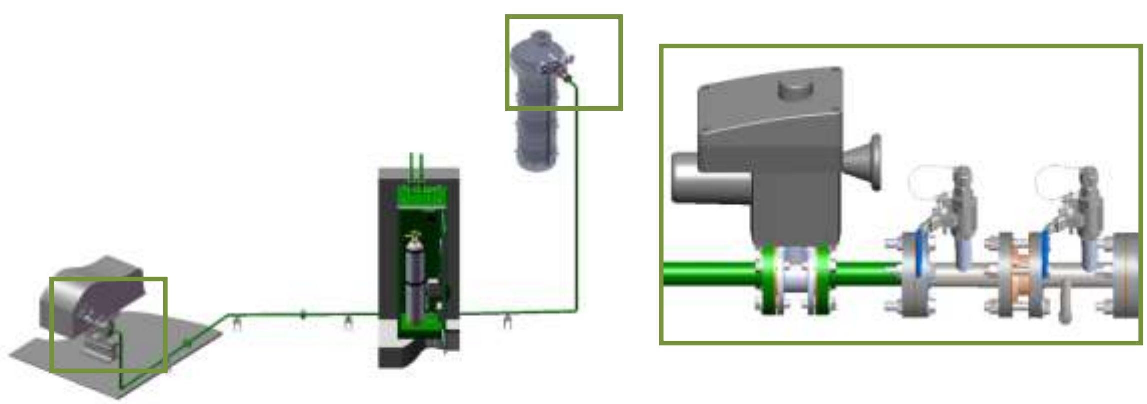
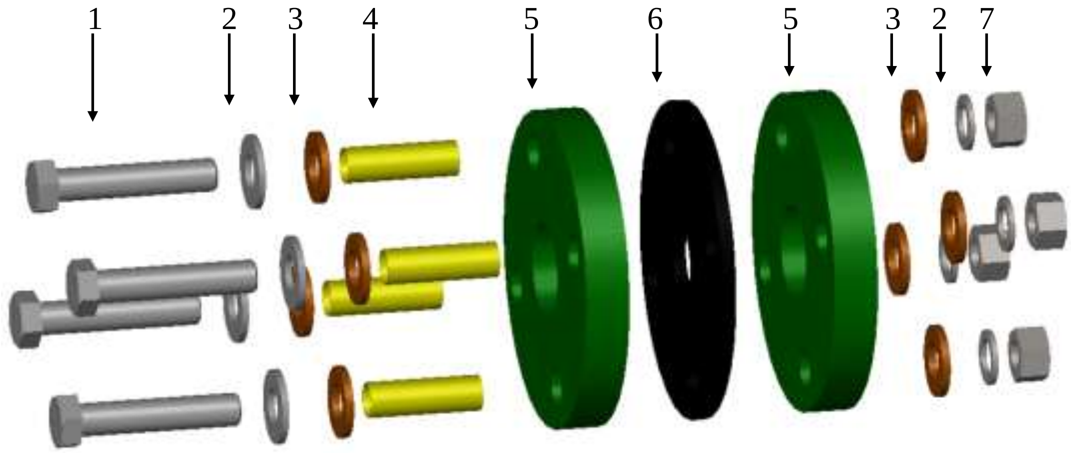


Figure 69: Electro Valve for Transformer and OLTC

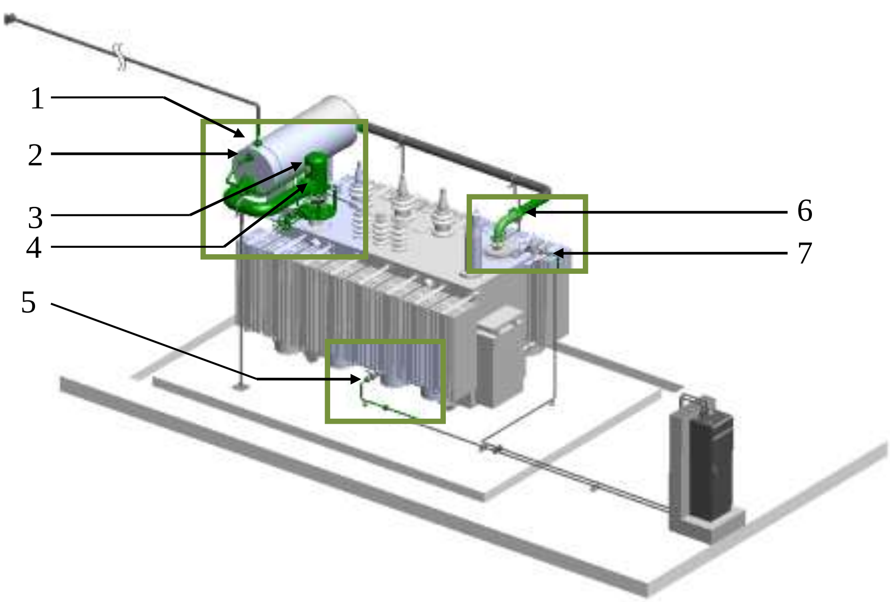
7.14 INSULATING FLANGE SET

The Insulating Flange Set (IFS) will isolate the entire transformer from components of the TP System that are in contact with the ground, ensuring effective sealing and electrical isolation. The purpose of the IFS is for Tank Earth Fault Protection. This kit is installed on the flanges of the ODP, GEP, and the IGIP, closest to the transformer.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	Bolt	5	Flange
2	Steel Washer *	6	Type "E" Central Gasket *
3	Insulating Washer *	7	Nut
4	Insulating Sleeve *	** Supplied with the TP if required*	

Figure 70: Insulating Flange Set



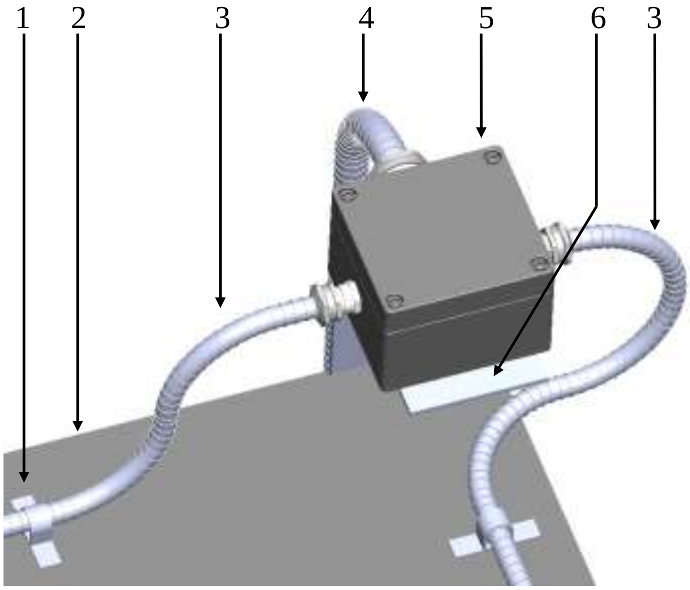
NO.	DESCRIPTION	NO.	DESCRIPTION
1	IFS for EGEP connection of OGST	5	IFS for IGIP connection to transformer
2	IFS for GEP connection of OGST	6	IFS for OLTC ODP
3	IFS for ODP connection of OGST	7	IFS for IGIP connection for OLTC
4	IFS for ODP and GEP		

Figure 71: Insulating Flange Set location for example shown

7.15 LINEAR HEAT DETECTOR

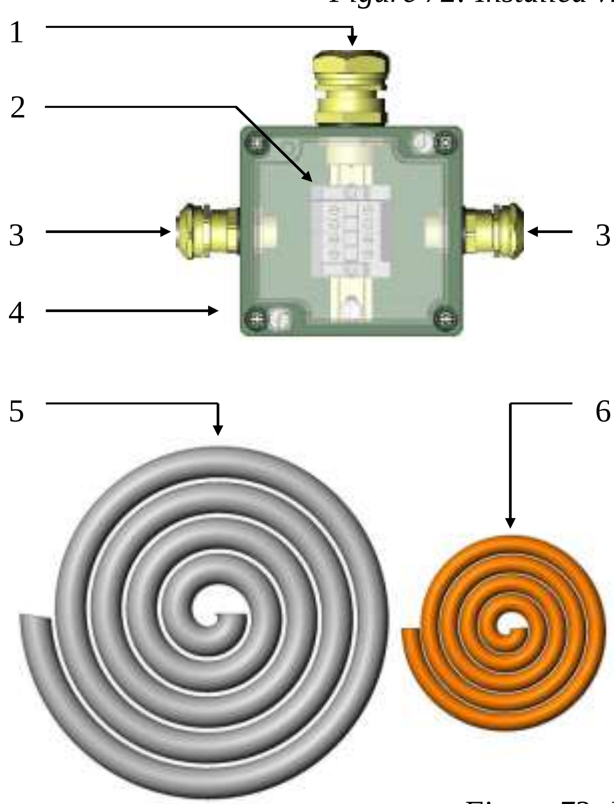
7.15.1 GENERAL OVERVIEW

The Linear Heat Detector (LHD) Set is installed on the transformer cover to detect external heat excess. An alarm will be received in the Control Box warning that an LHD signal has occurred. The LHD Set will aim to confirm along with the electrical protections to inject inert gas into the transformer to keep the transformer interior under secure conditions.



NO.	DESCRIPTION
1	LHD Cable securing collars
2	Transformer Tank Cover
3	LHD Cable inside Conduit
4	Fire Proof Cable inside Conduit
5	LHD Three Way Connection Box
6	LHD Mounting Bracket

Figure 72: Installed view of the LHD Set



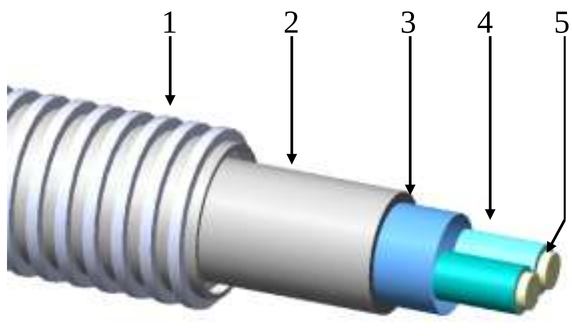
NO.	DESCRIPTION
1	LHD Three Way Connection Box
2	Three Way Connection Box Terminals
3	Connection entry for LHD Cable
4	Connection entry for Fire Proof Cable
5	Fire Proof Cable inside Conduit
6	LHD Cable inside Conduit

Figure 73: LHD Set

7.15.2 LHD Components Description

7.15.2.1 Linear Heat Detector Cable

The LHD Cable is a cable sensor comprised of two steel conductors individually insulated with a heat sensitive polymer. The insulated conductors are twisted together to impose a spring pressure between each other and wrapped with a protective tape. At the alarm temperature (280°F /138°C), the heat sensitive polymer insulation yields to the pressure upon it, permitting the inner conductors to move into contact with each other thereby initiating an alarm signal. This action takes place at the first heated point anywhere along the LHD Cable. The LHD has been designed for the indoors and outdoors. The LHD Cable will be supplied within the TP Scope of Supply. The LHD Cable should be secured to the transformer cover. The LHD Cable securing collars are part of the client's scope of supply.



NO.	DESCRIPTION
1	Conduit
2	Outer Jacket
3	Protective Tape
4	Heat Sensitive Polymer
5	Steel Conductors (2-Core Cable)

Figure 74: Linear Heat Detector Cable

a) Activation

The entire length of LHD Cable is a normally open conventional circuit and a small voltage is continuously applied at one end.

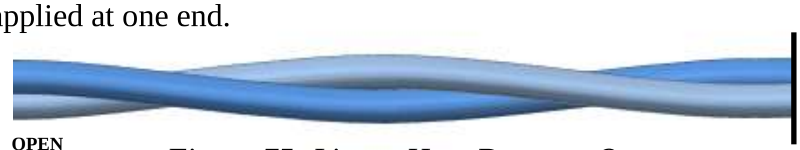


Figure 75: Linear Heat Detector Open

If a portion of the LHD Cable is exposed to heat above its rated alarm temperature, the heat sensitive polymer breaks down and a short occurs at that point. The current will then be free to flow through the loop, sending an alarm to the Control Box.

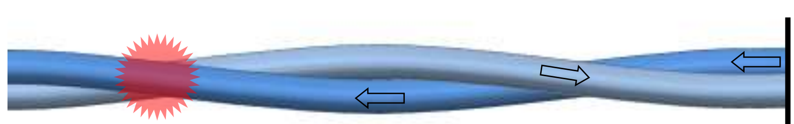


Figure 76: Linear Heat Detector closes after alarm temperature

b) LHD Length

P_{TRANS} = Perimeter of Transformer
P_{OLTC} = Perimeter of OLTC
P_{OCB} = Perimeter of OCB
n_1 = Number of OLTC
n_2 = Number of OCB

Perimeter of the Transformer
$P_{TRANS} = a + b + c + d$

Total Perimeter
$P_{TOTAL} = P_{TRANS} + (n_1)P_{OLTC} + (n_2)P_{OCB}$

If, P_{TOTAL} < 25 meters → 25 meters of LHD Cable.

If, P_{TOTAL} > 25 meters → order 50 meters of LHD Cable.

If, P_{TOTAL} > 50 meters → More than 50 meters of LHD Cable + 2 way connection box.

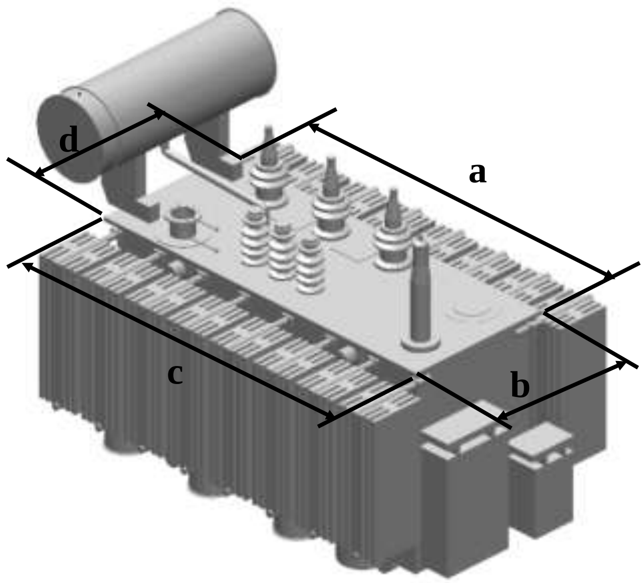
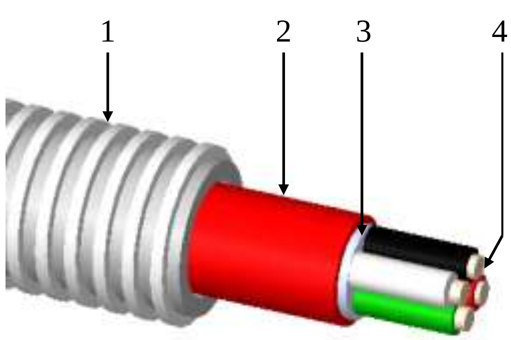


Figure 77: Linear Heat Detector Cable

The calculations above are approximations and the total length will also include margins to ensure sufficient cable length for connections and routing.

7.15.2.2 Fire Proof Cable

The Fire Proof Cable is utilized to connect the 3-Way Connection Box with the electrical interconnection box or Marshalling box. The 3-Way Connection Box should be installed on the transformer cover near the electrical interconnection box, reducing the amount of Fire Proof Cable necessary for the installation.



NO.	DESCRIPTION
1	Conduit
2	PVC Jacket
3	Aluminum Foil Shield
4	Copper Conductor

Figure 78: Fire Proof Cable

7.15.2.3 3-Way Connection Box

The 3-Way Connection Box is a connection box that will join the LHD Cable installed on the transformer cover and the electrical interconnection box or Marshalling Box. The 3-Way Connection Box should be installed on the transformer cover near the electrical interconnection box.

Figure 79: Three-Way Connection Box

7.15.2.4 2-Way Connection Box

The 2-Way Connection Box is a connection box that will allow additional length of LHD Cable to be installed. When the length of the LHD Cable is longer than 50 meters (164 ft), then a 2-Way Connection Box will need to be installed on the transformer cover to allow the proper installation of the LHD.

Figure 80: Two-Way Connection Box

7.15.2.5 Connection Box Bracket

The Connection Box Bracket is to be installed to mount the 3-Way Connection Box. The bracket is to be installed on the transformer cover near the electrical interconnection box. An additional bracket will need to be installed at the appropriate location for a 2-Way Connection Box if the LHD Cable is longer than 50 meters (164 ft) in length. The brackets are part of the client's scope of supply.

Figure 81: Mounting Brackets

7.16 TP MONITORING SYSTEM

7.16.1 CONTROL BOX DESCRIPTION

7.16.1.1 General Overview

The Control Box defines the TP operation logic. The Control Box is the monitoring device of the entire TP. All alarm signals will be indicated acting in the Prevention, Extinction, or Out of Service mode. The Electrical Diagram and Electrical Interconnection of the Control Box depend on the configuration of the TP. The Control Box is designed for indoors only and should be installed in the visible location inside the Control Room. The Control Box consist of four mounting point located on the back surface. The Control Box is to be mounted in the Control Room. The Control Box can be mounted in customer frame work such as the figure below.

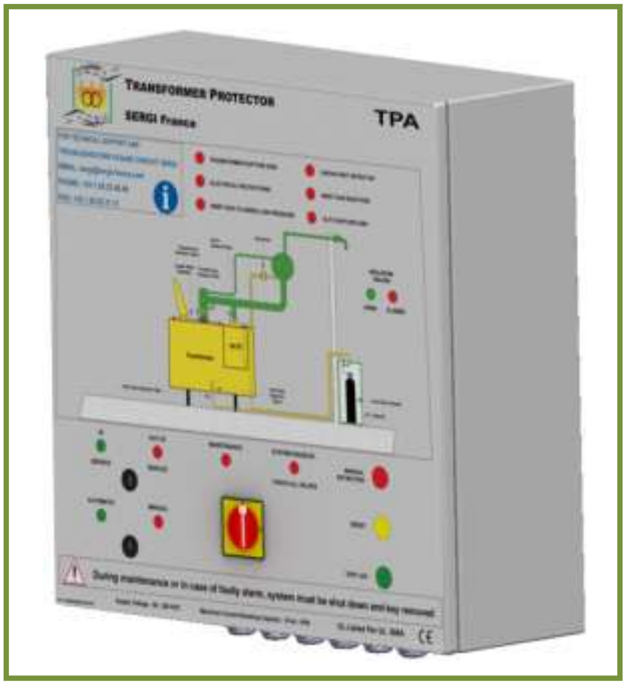
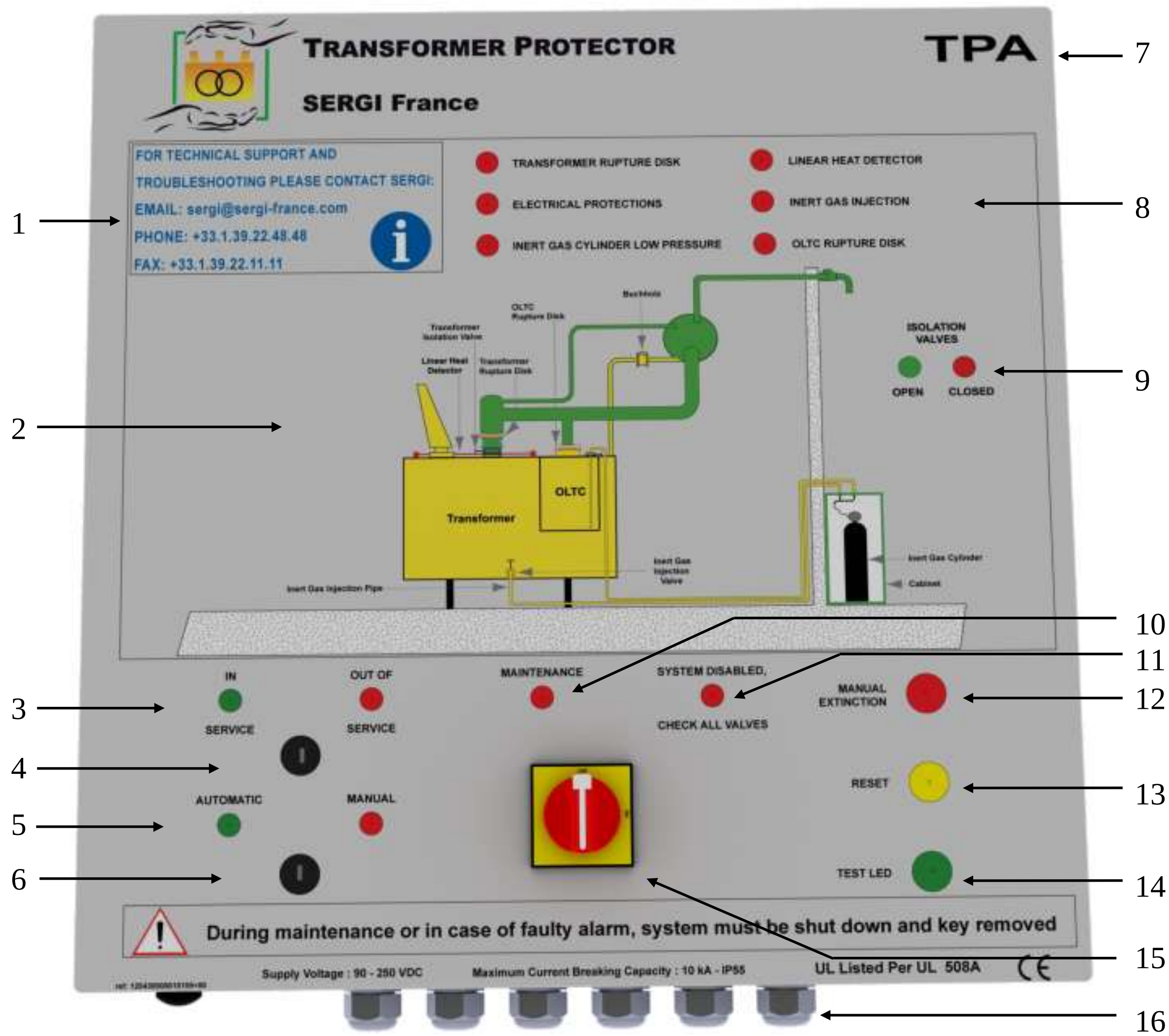


Figure 82: Control Box located in the Plant Control Room

7.16.1.2 Control Box

The Control Box size and items may vary according to the TP system design. The Standard LEDs found on this part of the Control Box are: Transformer Rupture Disk, Electrical Protection, Inert Gas Cylinder Low Pressure, Linear Heat Detector, and Inert Gas Injection. Shown below is an example of the front of a Control Box.



NO.	DESCRIPTION	NO.	DESCRIPTION
1	Contact Information	9	Transformer Isolation Valve LEDs
2	Synoptic	10	Maintenance LED
3	In Service (Green LED) /Out of Service (Red LED)	11	System Disabled LED
4	Turn Key for In Service/Out of Service	12	Manual Activation Push Button
5	Automatic (Green LED)/Manual (Red LED)	13	Reset Push Button
6	Turn Key for Automatic/Manual	14	Test LED Push Button
7	TP Configuration	15	Isolator
8	TP system LEDs (vary with design)	16	Control Box Glands

Figure 83: TPA Control Box Example

7.16.2 CONTROL BOXES RACK CABINET (OPTION)

The Control Boxes Rack Cabinet is a substitute of the Control Box, which can replace 2 (two) supply racks and 6 (six) system racks. The components found depend on the TP components installed and the TP configuration. The Control System is designed for indoors only and should be installed in a visible location in the Control Room.

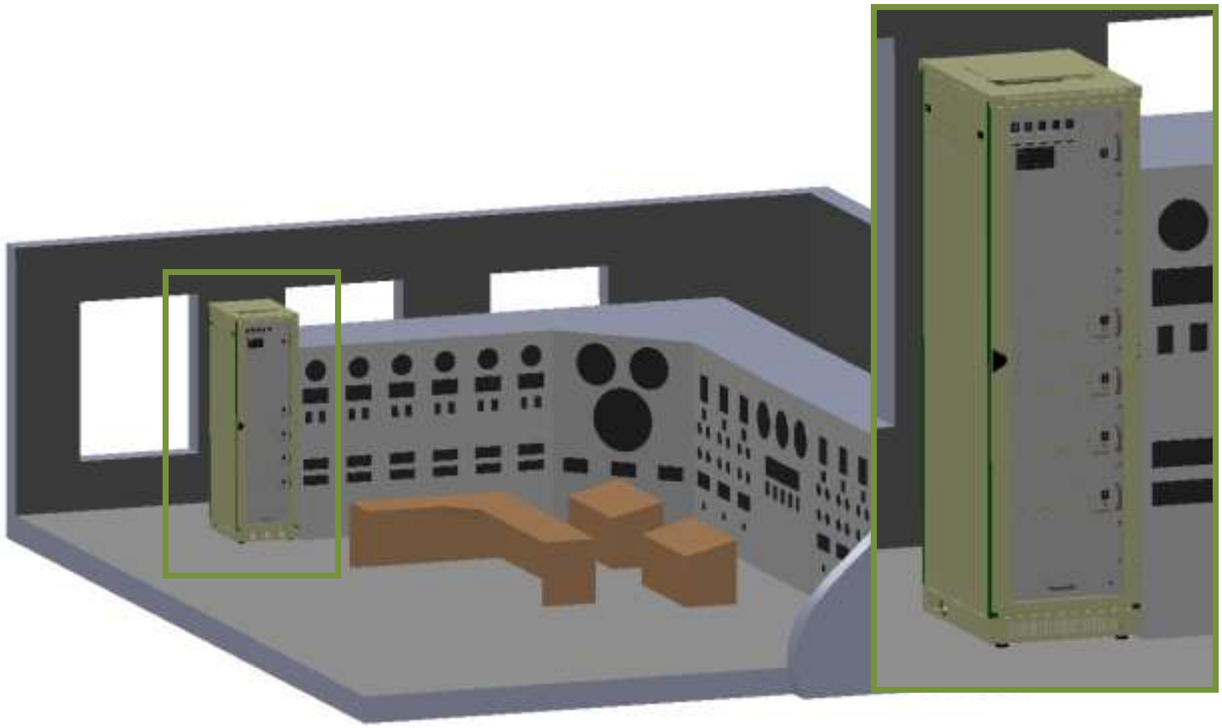


Figure 84: Control Boxes Rack Cabinet

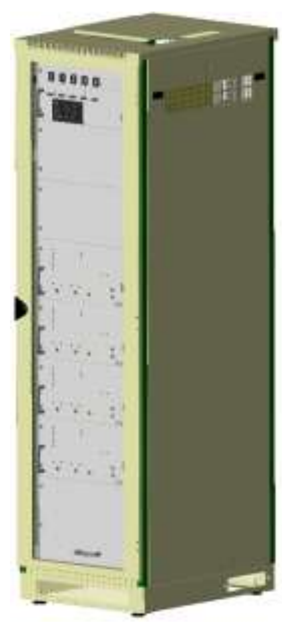


Figure 85: Control Boxes Rack Cabinet

8 ELECTRICAL CONNECTIONS

8.1 SYSTEM COMPONENT INTERCONNECTION

A general schematic of the cables for the interconnection of some of the system subcomponents are shown in the figure below.

All cabling is supplied by the client and it is recommended to use shielded type, especially Cable 2, Cable 4, and Cable 6 shown in schematic below.

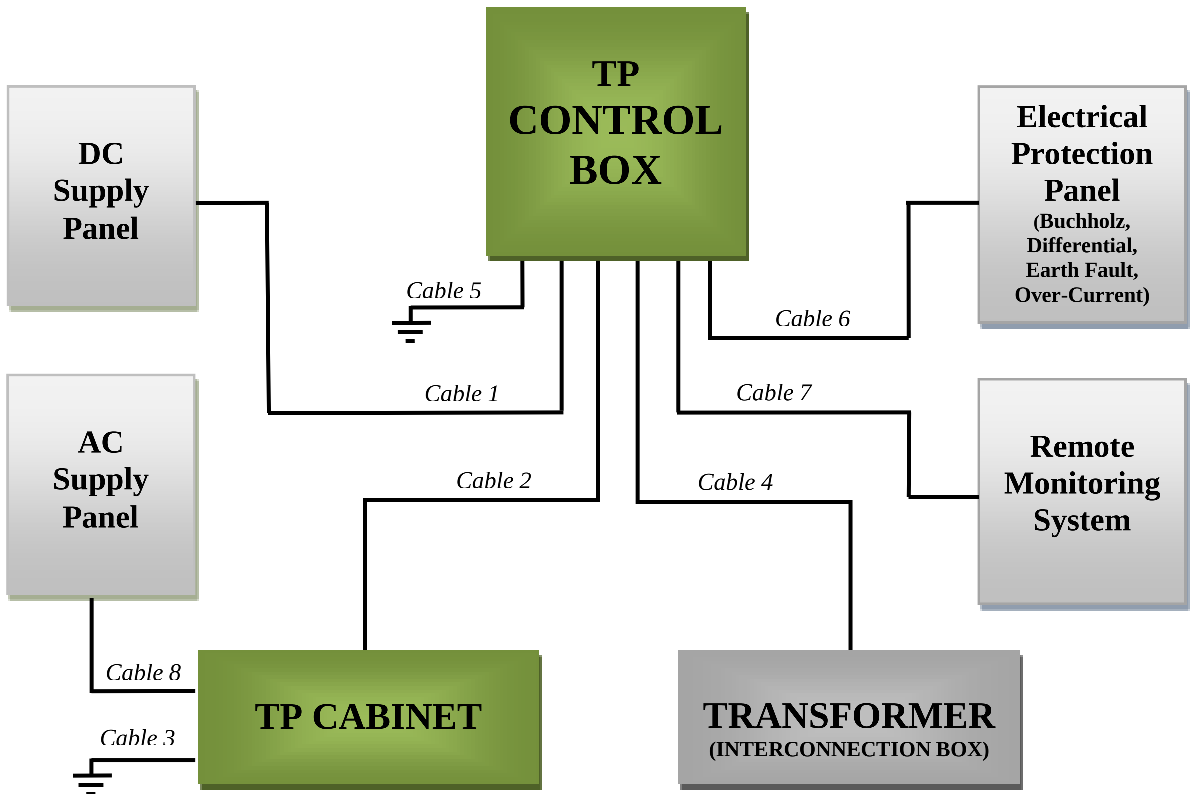


Figure 86: Schematic of Cable Wiring for an Example Installation

8.2 LOGIC OF OPERATION

The TP could be activated in two different modes:

a) Prevention Mode

As soon as the TP receives the Rupture Disk signal and an Electrical Protection signal (Buchholz, Differential, Earth Fault, or Over current) the system will be activated in Prevention Mode, automatically injecting inert gas after 5 minutes.

b) Extinction Mode

If the Control Box receives a signal from the LHD and an Electrical Protection signal, the system will be activated in Extinction Mode, automatically injecting the inert gas instantaneously.

c) Automatic Inert Gas Injection

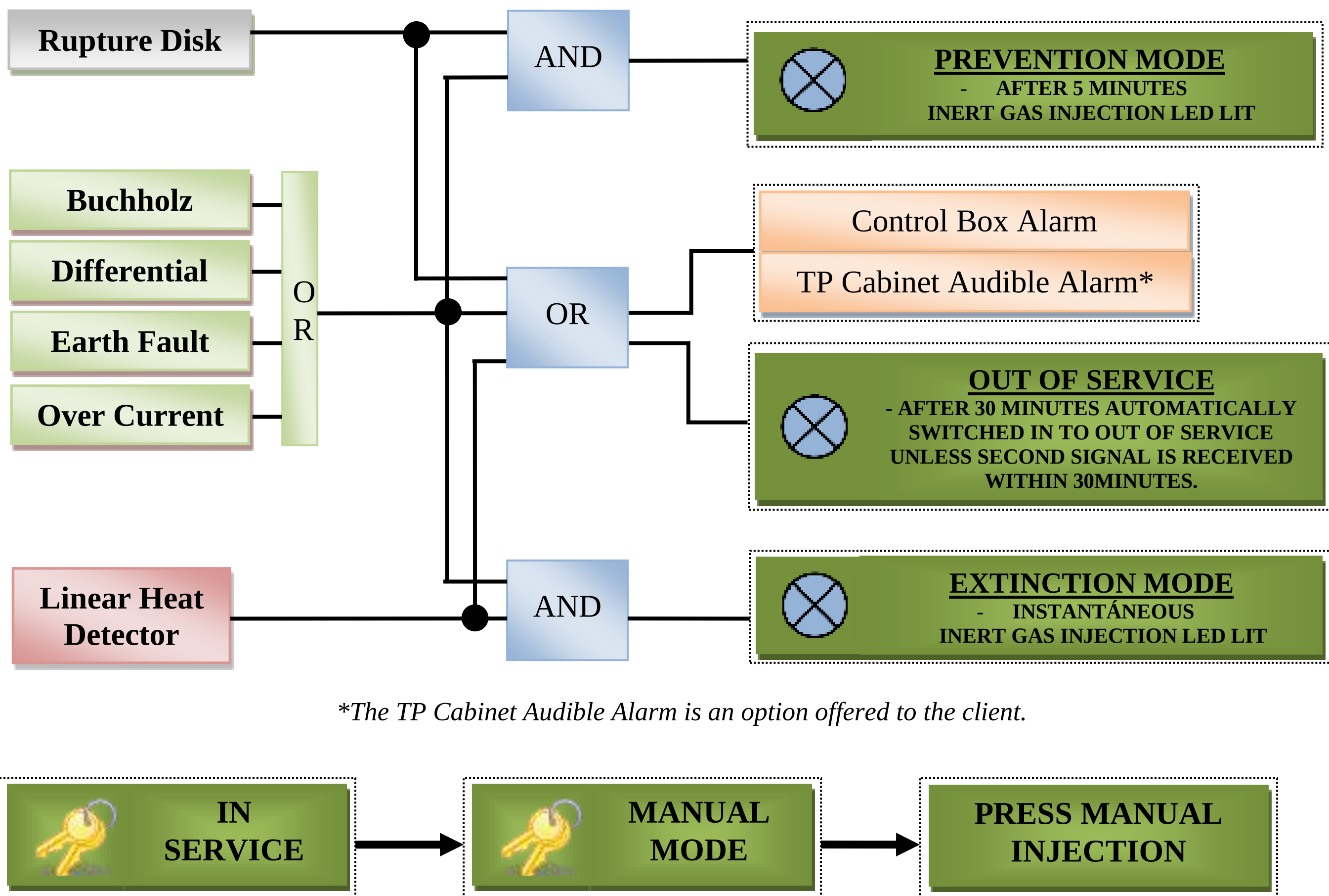


Figure 87: Standard Logic of Operation

If the Control Box receives only one signal (Rupture Disk, LHD or Electrical Protection) during a 30 minute period, the system will automatically switch into the "Out of Service" mode.

d) Logic of Injection

The Inert Gas Injection into the transformer, OLTC, and OCB may be done in several different methods. The Injection may be performed automatically or manually depending on the location of injection and option chosen by the client. Below is described where the client may activate the injection of inert gas.

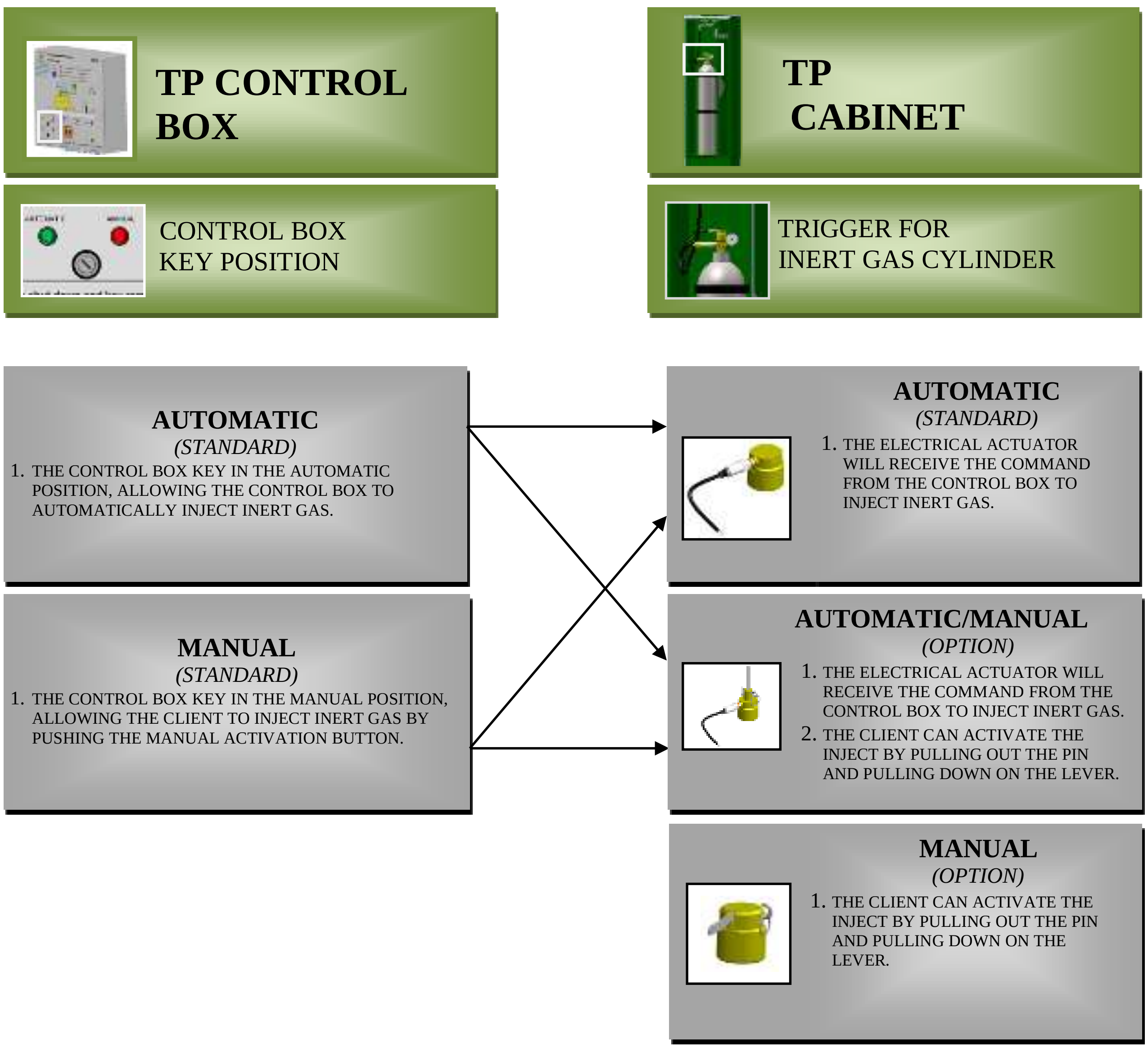


Figure 88: Standard Logic of Inert Gas Injection

8.3 RUPTURE DISK BURST INDICATORS

8.3.1 SINGLE RUPTURE DISK BURST INDICATOR

The DS activation information is sent from the Rupture Disk Burst Indicator to the transformer electrical connection box, where cables must be linked. According to the amount of Rupture Disk installed on the transformer, the end user must prepare spare terminal blocks in the transformer interconnection box. Each Burst Indicator must be linked in the transformer electrical connection box by 2 x 1.5 mm² (14 AWG) cables. These cables are not provided.

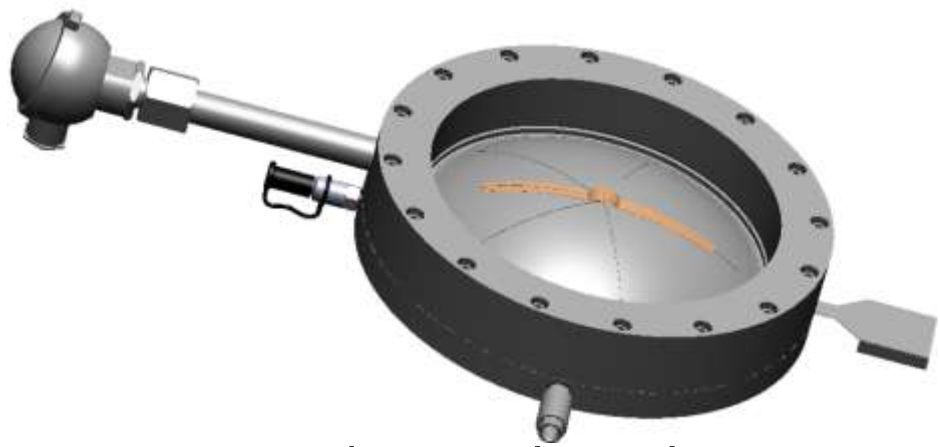


Figure 89: Single Rupture Disk Burst Indicator

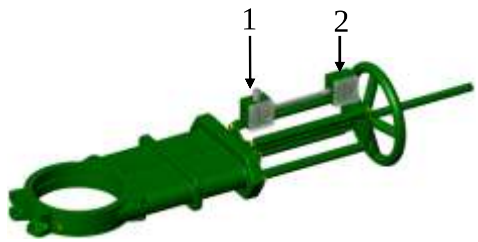
8.3.2 DOUBLE RUPTURE DISK BURST INDICATOR (OPTION)

The Double Rupture Disk Burst Indicator is an option for clients which include two burst indicators on the Rupture Disk. One burst indicator is for the original purpose of providing information to the Control Box indicating the Rupture Disk has been opened. The second burst is used to trip the transformer breaker directly without other signals.

Figure 90: Double Rupture Disk Burst Indicator

8.4 ISOLATION VALVE

The Isolation Valve consists of two position detectors which will indicate the open and closed position of the valve. These connections are to be connected to the interconnection box (4 x $1.5mm^2$ (14 AWG)) and routed to the Control Box (minimum section depends on distance).



NO.	DESCRIPTION
1	Valve Fully Closed Detector
2	Valve Fully Opened Detector

Figure 91: Isolation Valve

8.5 ELECTRICAL PROTECTIONS

The client is to provide the Electrical Protection (Buchholz Relay, Over-Current, Earth Fault, and Differential) signal to the Control Box. This is critical because the logic of the TP functions with the Electrical Protection signals.

8.6 LINEAR HEAT DETECTOR

The LHD is to be connected to the Interconnection Box which will be connected with the Control Box. This signal will work in the TP Extinction Mode.

8.7 TP CABINET ELECTRICAL CONNECTION

The TP Cabinet is to be provided with an electrical source for the electrical appliances that the TP Cabinet consists.

a) Heater

The Heater located inside the TP Cabinet will maintain a temperature above 15°C (59°F). The Heater is used to avoid freezing and condensation to keep the TP Cabinet without any corrosion. The nominal voltage for the heater is 110-240 VAC.

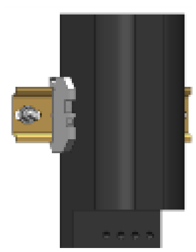


Figure 92: TP Cabinet Heater

b) Hygrostat (Option)

The Hygrostat measures the relative humidity inside the TP Cabinet. It is used to reduce the amount of humidity inside the TP Cabinet. The Hygrostat is connected inside the TP Cabinet with a 3-pole terminal for 2.5 mm^2 (12 AWG) electrical connection.

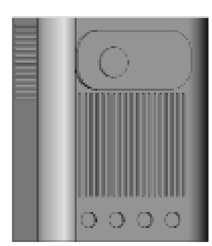


Figure 93: Hygrostat

c) TP Cabinet Audible Alarm Set (Option)

The TP Cabinet Audible Alarm Set is used to warn people located outside of an event signalized by the Control Box. The Audible Alarm is to be connected to the TP Cabinet with a 2 x 1.5 mm^2 (14 AWG) electrical wire for a distance up to 300 meters (984 ft).

Figure 94: TP Cabinet Audible Alarm Set

d) Light Set for TP Cabinet (Option)

The Light Set for TP Cabinet will allow lighting inside the TP Cabinet while making an inspection of the TP Cabinet. The light is to be connected to the TP Cabinet with a 2 x 1.5 mm^2 (14 AWG) electrical wire.

Figure 95: Light Set for TP Cabinet

e) Electrical Actuator

The Electrical Actuator energy source will function once the Control Box sends the signal for the Electrical Actuator to be activated. The Electrical Actuator is connected to Automatic Trigger for Inert Gas Cylinder. The Electrical Actuator is to be connected to terminals 930 and 931 inside Box Number 3 of the TP Cabinet.

Figure 96: Electrical Actuator

8.8 CONTROL BOX

The finished Control Box degree of protection is rated a minimum IP55. The door is earthed to the body of the Control Box via a green and yellow earth cable. Wires must be equipped with labels in conformity with the electrical drawings. All terminals must employ screw connections, where no soldering is permitted. The Control Box will be fitted with six PG21 cable glands which are to be used for all wiring entering or exiting the Control Box. The terminal blocks for the connection of 4 mm^2 (10 AWG) for all input and output including voltage and 6 mm^2 (9 AWG) for earth connection.

9 PIPING REQUIREMENTS (CLIENT'S SCOPE OF SUPPLY)

9.1 OIL DRAIN PIPE

The ODP will allow the evacuation of explosive gases and oil during the TP activation. The ODP will connect the transformer DS with the OGST, which will be considered the principal ODP. The ODP size will correspond to the transformer DS size. The OLTC and OCB/OBCB DS ODP will connect to the principal ODP using a T-Piece. The ODP supports are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft).

No additional valves are to be installed along the routing of the ODP. Pipe fitting are to be used when assembling the GEP together.

The DS and OGST should not support the weight of the ODP.

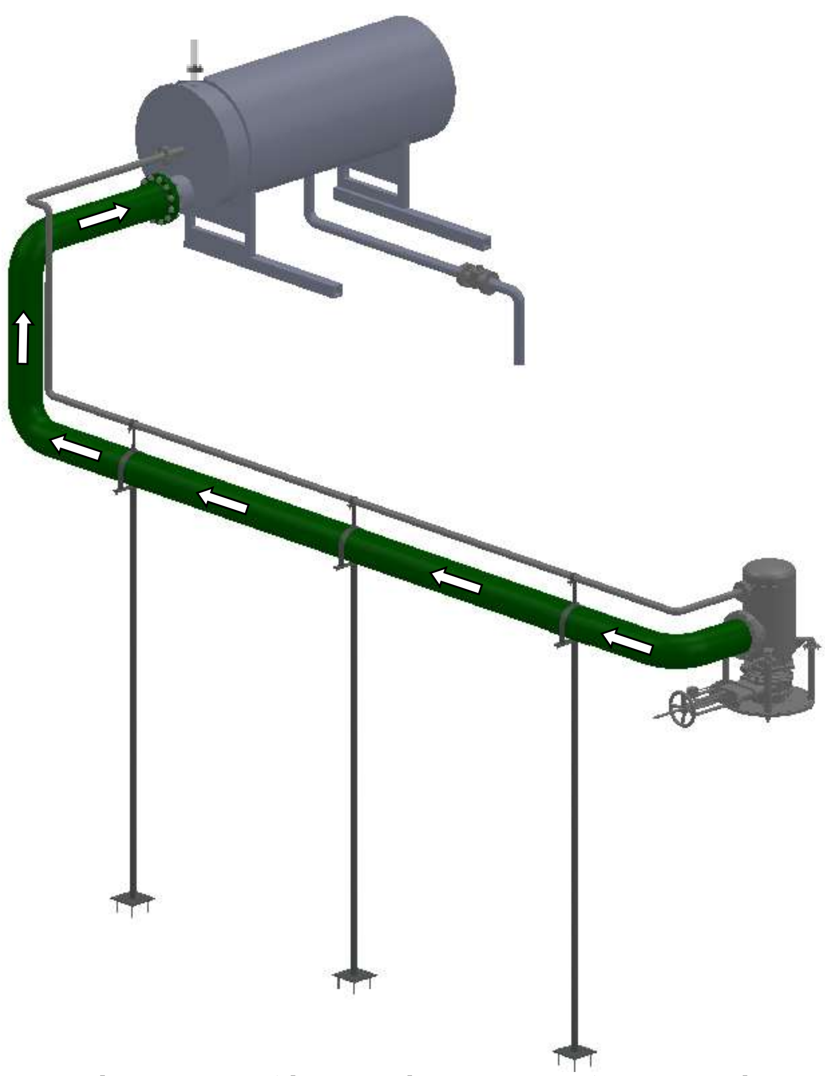


Figure 97: Oil Drain Pipe (shown with green piping) – VDS with SOGST

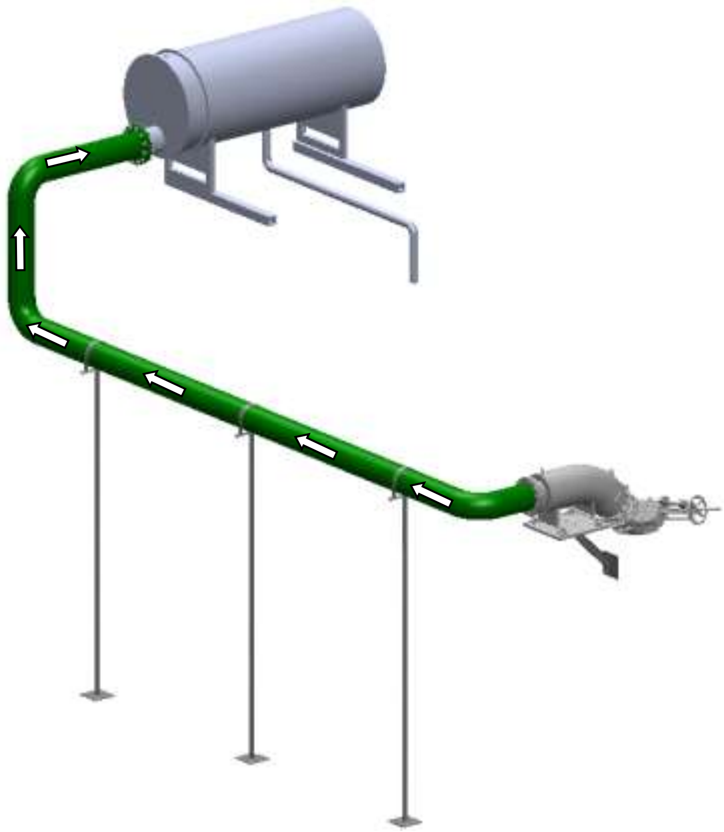


Figure 98: Oil Drain Pipe (shown with green piping) – 45°DS with SOGST

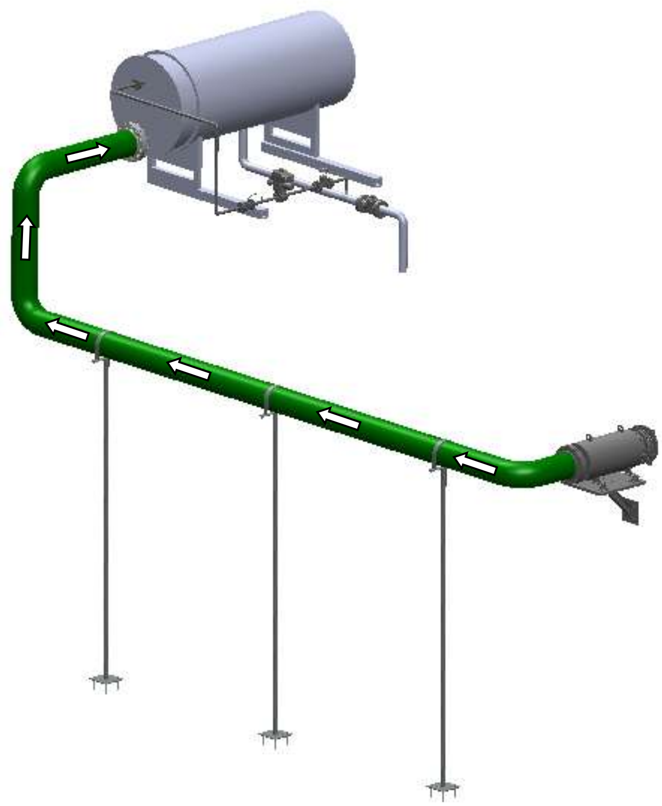


Figure 99: Oil Drain Pipe (shown with green piping) – HDS with SOGST

9.2 GAS EVACUATION PIPE

The GEP will allow evacuating the gases and inert gas after a TP activation. The GEP configuration is installed based on the TP type (VDS or HDS). The GEP supports are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft).

No additional valves are to be installed along the routing of the GEP.
Pipe fitting are to be used when assembling the GEP together.

9.2.1 VDS GEP

The VDS consists of a DN 25 (1-inch) connection for the GEP which is located on the DC. The GEP will be routed from transformer DS GEP connection to the OGST GEP connection.

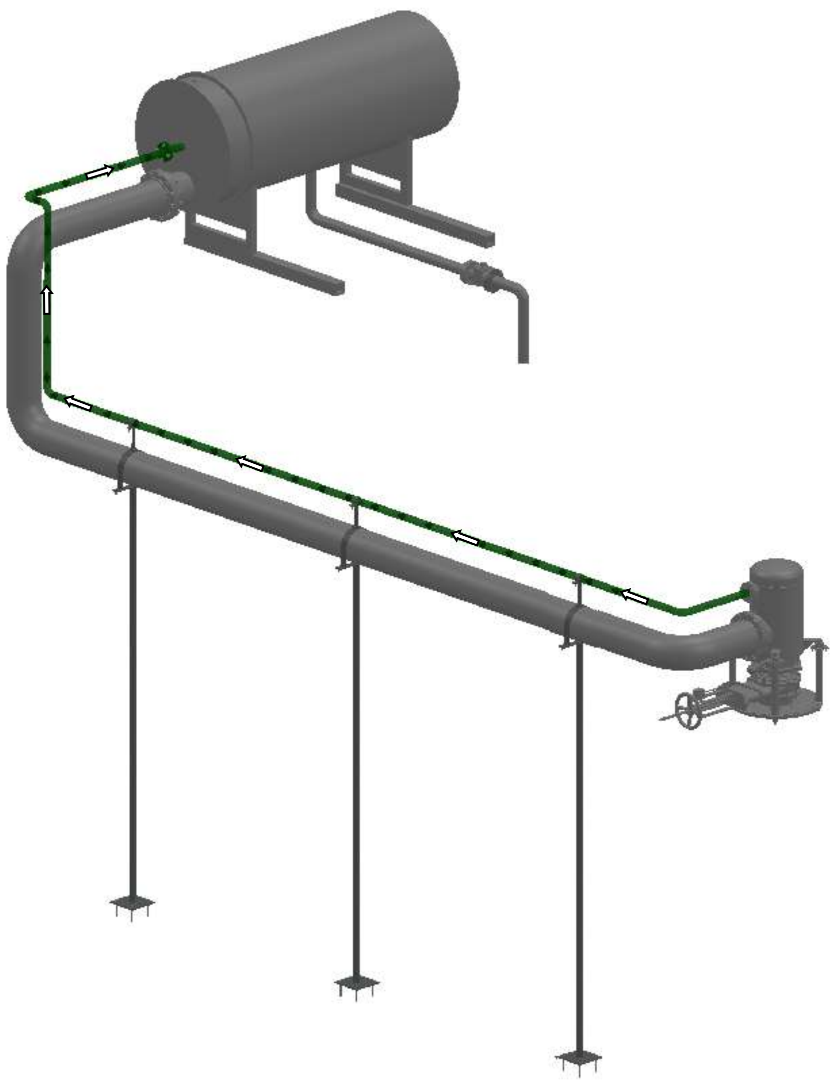
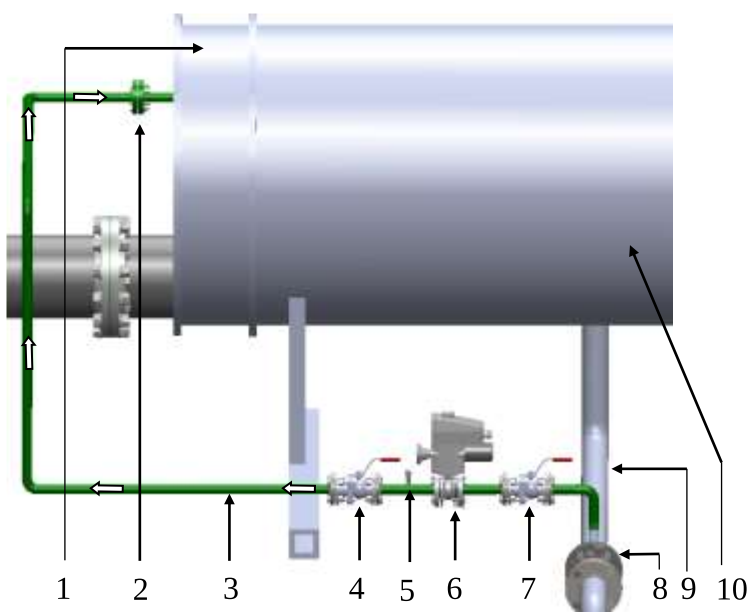


Figure 100: Gas Evacuation Pipe (shown with green piping) – VDS

9.2.2 **HDS GEP**

Since the HDS is located below the transformer cover height there will be gases collected at the transformer cover which need to be evacuated in case of an activation. For this reason a DN25 (1-inch) GEP will be routed from the T-piece (located between the Buchholz Relay and the transformer conservator tank) to the OGST. If equipped with a Conservator Shutter, the GEP set should be located between the Buchholz and the Conservator Shutter.

Figure 101: Gas Evacuation Pipe (shown with green piping) – HDS



NO.	DESCRIPTION
1	SOGST
2	OGST GEP inlet
3	GEP
4	Ball Valve *(supplied by SF)*
5	Air Vent *(supplied by SF)*
6	Electro Valve *(supplied by SF)*
7	Ball Valve *(supplied by Client)*
8	Buchholz
9	Conservator piping
10	Transformer Conservator Tank

Figure 102: Gas Evacuation Pipe Installation Components

9.3 EXPLOSIVE GAS EVACUATION PIPE

The EGES refers to the EGEP and the AIS. After a TP activation and injection of inert gas, all explosive gases will be evacuated from the transformer and TP equipment. The EGEP should be routed from the OGST with DN 50 (2-inch) piping. The EGEP supports are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft).

No additional valves are to be installed along the routing of the EGEP.
Pipe fitting are to be used when assembling the GEP together.

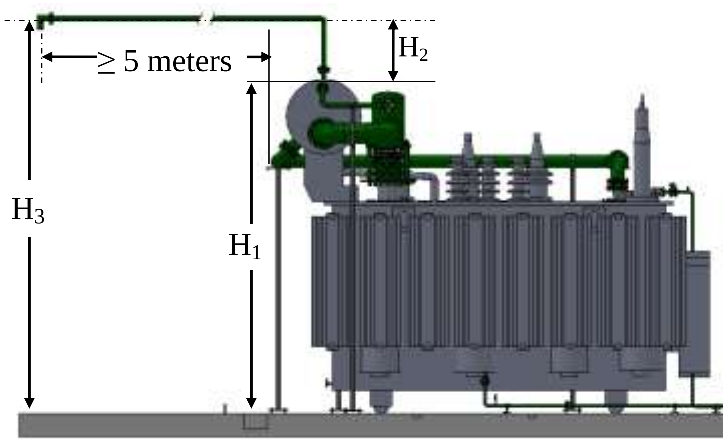
9.3.1 EGEP WITH SOGST

The end of the EGEP is to be found at a minimum of 5 meters (16.4 ft) away from the transformer and all surrounding equipment, at least 5 meters (16.4 ft) from the ground, and with a minimum height of 100 mm (3.9 inches) above the OGST.

H_1 = Distance from the top of the transformer conservator tank to the ground.
H_2 = Distance from the EGEP axis to the top part of the OGST.
H_3 = Distance from the AIS to the ground.

If, $H_1 \leq 4.9$ meters (16.1 ft) $\begin{cases} H_3 = 5.0 \text{ meters (16.4 ft)} \\ H_2 = H_3 - H_1 \end{cases}$

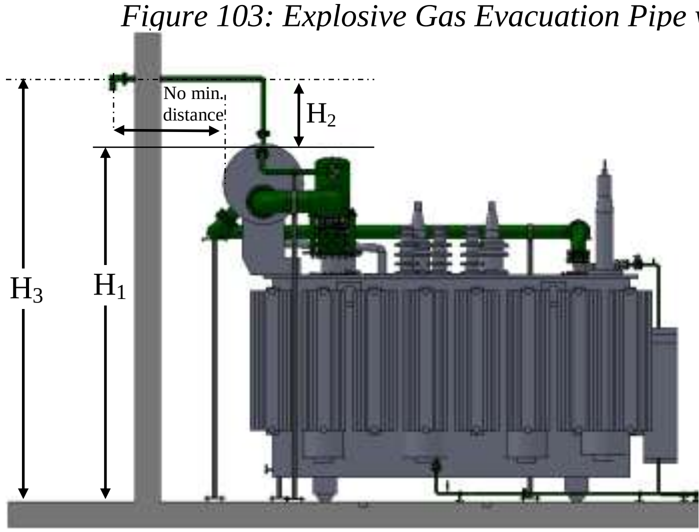
If, $H_1 > 4.9$ meters (16.1 ft) $\begin{cases} H_2 = 0.1 \text{ meters (0.33 ft)} \\ H_3 = H_1 + H_2 \end{cases}$



EXAMPLE 1	NO.	LENGTH
	H_1	3.0 meters (9.8 ft)
	H_2	2.0 meters (6.6 ft)
	H_3	5.0 meters (16.4 ft)

EXAMPLE 2	NO.	LENGTH
	H_1	5.0 meters (16.4 ft)
	H_2	0.1 meters (0.33 ft)
	H_3	5.1 meters (16.7 ft)

Figure 103: Explosive Gas Evacuation Pipe without firewall (SOGST)



EXAMPLE 1	NO.	LENGTH
	H_1	3.0 meters (9.8 ft)
	H_2	2.0 meters (6.6 ft)
	H_3	5.0 meters (16.4 ft)

EXAMPLE 2	NO.	LENGTH
	H_1	5.0 meters (16.4 ft)
	H_2	0.1 meters (0.33 ft)
	H_3	5.1 meters (16.7 ft)

Figure 104: Explosive Gas Evacuation Pipe with firewall (SOGST)

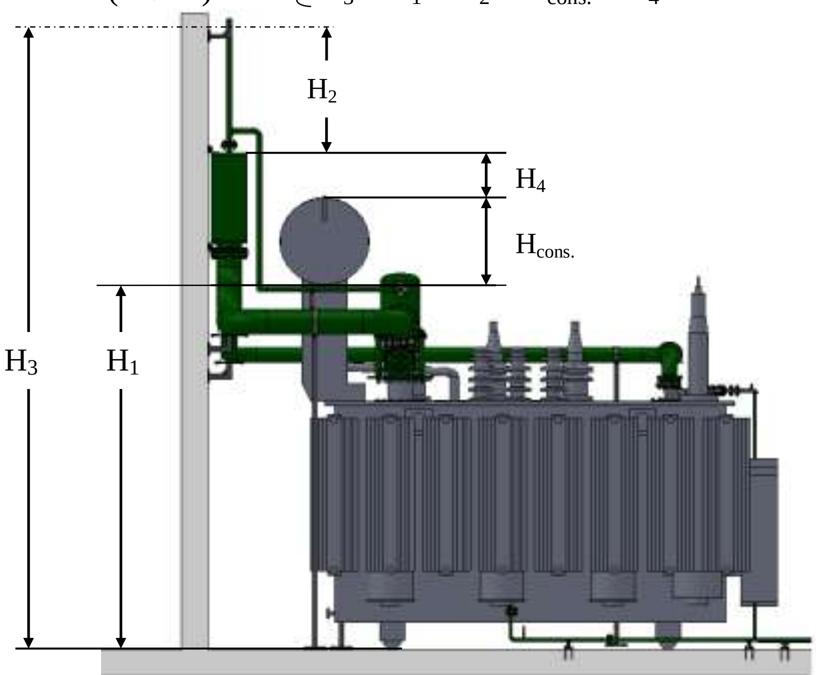
9.3.2 EGEP WITH WOGST

The end of the EGEP is to be found at a minimum of 5 meters (16.4 ft) away from the transformer and all surrounding equipment, at least 5 meters (16.4 ft) from the ground, and with a minimum height of 100 mm (3.9 inches) above the OGST.

H_1 = Distance from the bottom of the transformer conservator tank to the ground.
H_2 = Distance from the EGEP axis to the top part of the OGST.
H_3 = Distance from the AIS to the ground.
H_4 = Distance from top of OGST above the top of transformer conservator tank (≥0.1 meter).

If, $H_1 \leq 3.8$ meters (12.5 ft) $\begin{cases} H_3 = 5.0 \text{ meters (16.4 ft)} \\ H_2 = H_3 - H_1 - H_{cons.} - H_4 \end{cases}$

If, $H_1 > 3.8$ meters (12.5 ft) $\begin{cases} H_2 = 0.1 \text{ meters (0.33 ft)} \\ H_3 = H_1 + H_2 + H_{cons.} + H_4 \end{cases}$



	NO.	LENGTH
EXAMPLE 1	H_1	3.0 meters (9.8 ft)
	H_2	0.9 meters (2.9 ft)
	H_3	5.0 meters (16.4 ft)
	H_4	0.1 meters (0.33 ft)
	$H_{cons.}$	1 meter (3.28 ft)

	NO.	LENGTH
EXAMPLE 2	H_1	5.0 meters (16.4 ft)
	H_2	0.1 meters (0.33 ft)
	H_3	6.2 meters (20.3 ft)
	H_4	0.1 meters (0.33 ft)
	$H_{cons.}$	1 meter (3.28 ft)

Figure 105: Explosive Gas Evacuation Pipe with firewall (WOGST)

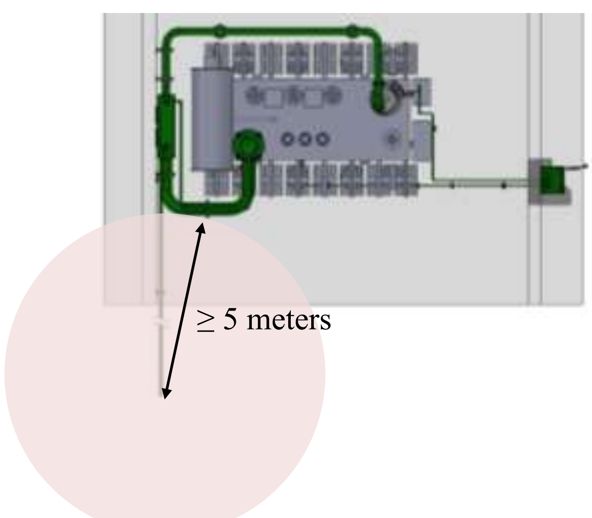


Figure 106: EGEP 5 meters away from transformer and surrounding equipment

9.3.3 EGEP WITH EOGST

The end of the EGEP is to be found at a minimum of 5 meters (16.4 ft) away from the transformer and all surrounding equipment, at least 5 meters (16.4 ft) from the ground, and with a minimum height of 100 mm (3.9 inches) above the OGST.

H_1 = Distance from top of Transformer Conservator to the ground.
H_2 = Distance from the EGEP axis to the top part of the OGST.
H_3 = Distance from the AIS to the ground.
H_4 = Distance from bottom of OGST above the top transformer conservator tank ($\geq$0.1 meter).

If, $H_1 \leq 3.8$ meters (12.5 ft) $\begin{cases} H_3 = 5.0 \text{ meters (16.4 ft)} \\ H_2 = H_3 - H_1 - H_{OGST} - H_4 \end{cases}$

If, $H_1 > 3.8$ meters (12.5 ft) $\begin{cases} H_2 = 0.1 \text{ meters (0.33 ft)} \\ H_3 = H_1 + H_2 + H_{OGST} + H_4 \end{cases}$

EXAMPLE 1

NO.	LENGTH
H_1	3.0 meters (9.8 ft)
H_2	0.9 meters (2.9 ft)
H_3	5.0 meters (16.4 ft)
H_4	0.1 meters (0.33 ft)
H_{OGST}	1 meter (3.28 ft)

EXAMPLE 2

NO.	LENGTH
H_1	5.0 meters (16.4 ft)
H_2	0.1 meters (0.33 ft)
H_3	6.2 meters (20.3 ft)
H_4	0.1 meters (0.33 ft)
H_{OGST}	1 meter (3.28 ft)

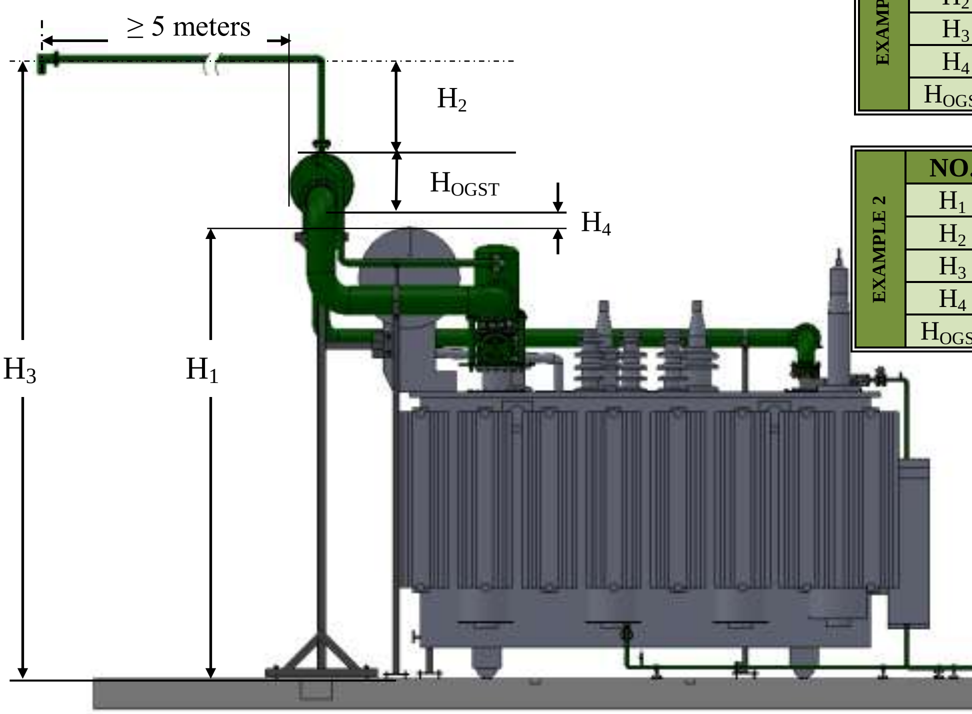


Figure 107: Explosive Gas Evacuation Pipe with firewall (EOGST)

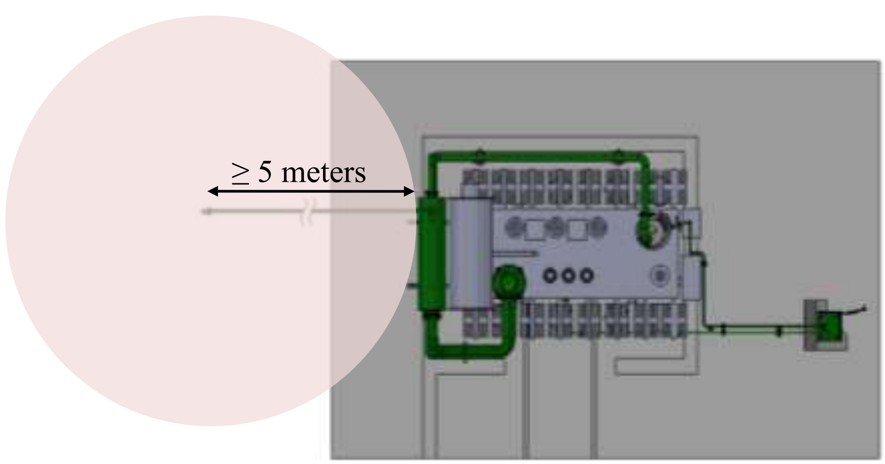


Figure 108: EGEP 5 meters away from transformer and surrounding equipment

9.4 INERT GAS INJECTION PIPE

The IGIP will allow the injection of inert gas from the TP Cabinet, to the transformer, OLTC (if applicable), and OCB (if applicable). The IGIP will be full of transformer oil while in the stand-by mode. The IGIP needs to be installed between 50 mm (2-inches) to 100 mm (4-inches) from the ground, avoiding possible corrosion of the piping due to water collection on the ground. The IGIP supports are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft). The proper connection for the IGIP routed to the transformer will be indicated on the manifold inside the TP Cabinet with a letter "T".

No additional valves are to be installed along the routing of the IGIP.
Pipe fitting are to be used when assembling the GEP together.

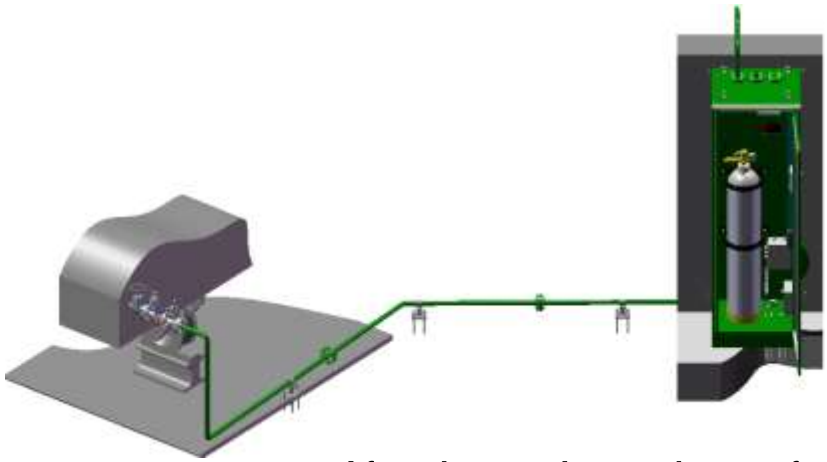


Figure 109: Inert Gas Injection Pipe routed from the TP Cabinet to the Transformer

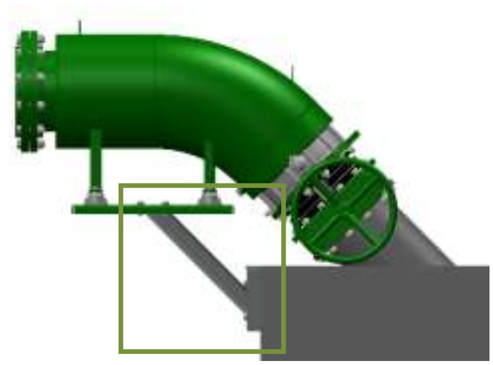
The IGIP for the Internal OLTC needs to be connected to the turret which will allow injection to the bottom of the OLTC, allowing all explosive gases to be evacuated with the inert gas. The IGIP for the External OLTC and OCB need to be connected on the drain valve which will allow inert gas injection through the bottom of each transformer component. The proper connection for the IGIP routed to the OLTC/OCB will be indicated on the manifold inside the TP Cabinet with a letter "A".

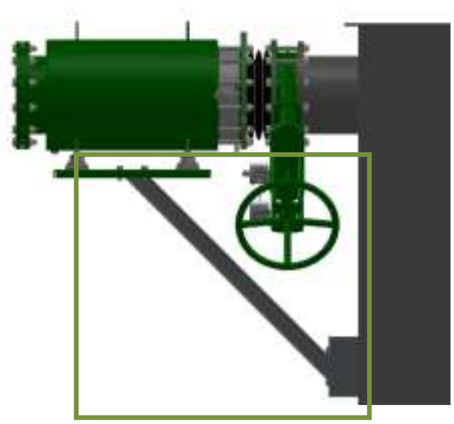
Figure 110: Inert Gas Injection Pipe routed from the TP Cabinet to the OLTC

9.5 SUPPORTS

9.5.1 DEPRESSURIZATION SET SUPPORT

The DS support provide the required rest to support the HDS and 45°DS. The support is to be fixed to the transformer wall and the DS support plate. All items are in the client's scope of supply. The whole DS Support is adjustable in all directions in a range of +/- 20 mm. Washers and bolts of size M16 are used to mount the DC to the I-beam Support, in the client's scope of supply.





NO.	DESCRIPTION
1	Mounting Plate for DS
2	I Beam DN75 (3-inch)
3	Mounting Plate attached to Mounting Bracket

Figure 111: I-Beam Assembly

9.5.2 OIL DRAIN PIPE SUPPORTS

The ODP support and clamp are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft) and as necessary. The ODP support shall properly support and secure the piping from any type of movement. Below are some examples of the supports that may be found for the ODP.

Support and clamp for ODP *Support and clamp for ODP* *Support for ODP*

Figure 112: Oil Drain Pipe Support Examples

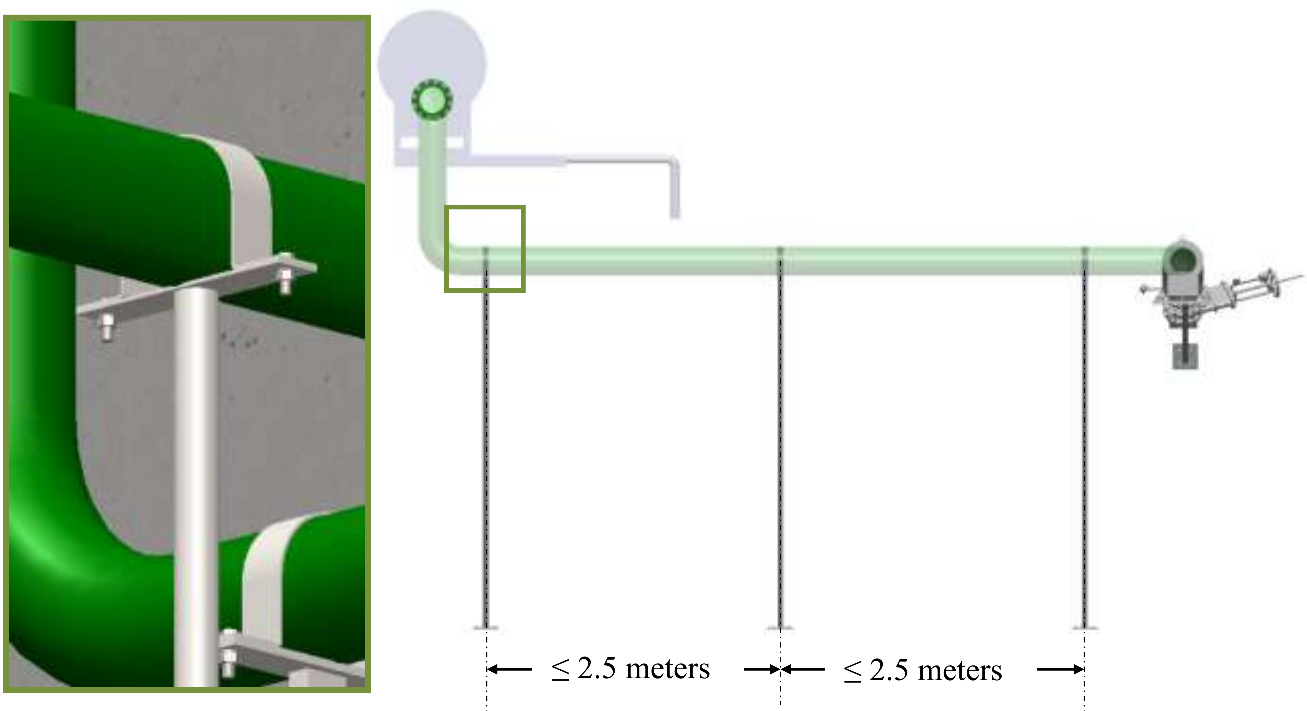


Figure 113: Oil Drain Pipe Support Example every 2.5 meters

Support and clamp when firewall exists

Figure 114: Oil Drain Pipe Support Example

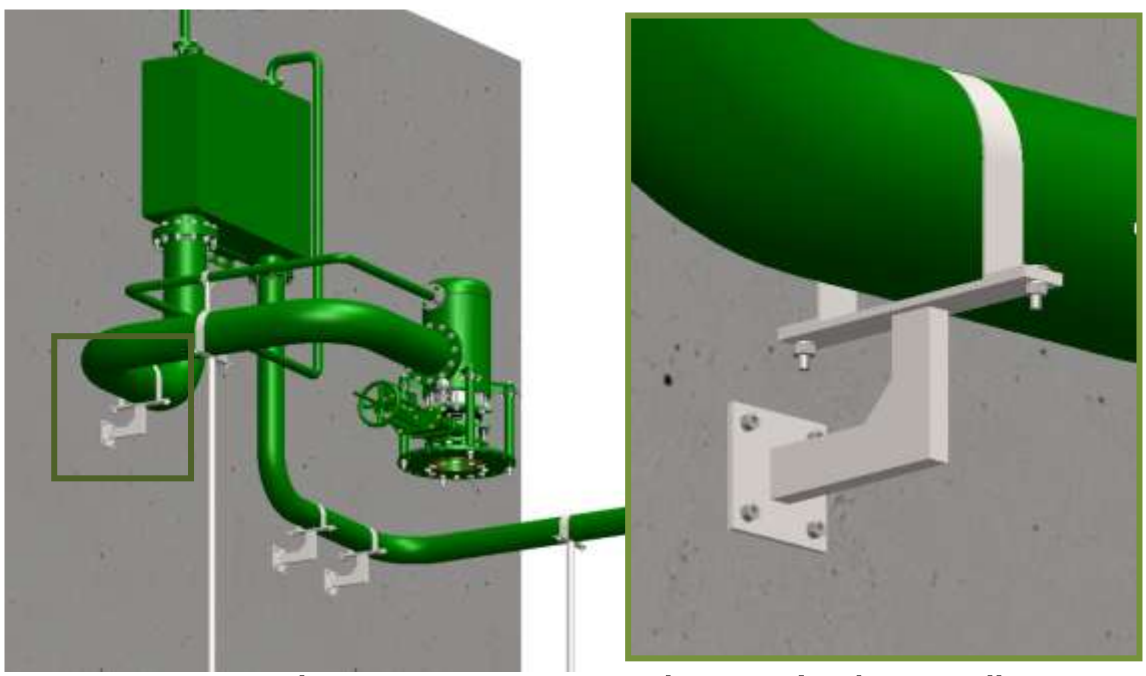


Figure 115: Oil Drain Pipe Support Example mounted to the Firewall

9.5.3 EXPLOSIVE GAS EVACUATION PIPE SUPPORTS

The EGEP is routed from the OGST to a safe environment. The EGEP support and clamp are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft) and as necessary. The EGEP support shall properly support and secure the piping from any type of movement. Below are some examples of the supports that may be found for the EGEP.

Support and clamp when firewall exist

Support and Clamp attached to the top of the firewall

Figure 116: Explosive Gas Evacuation Pipe Support Example.

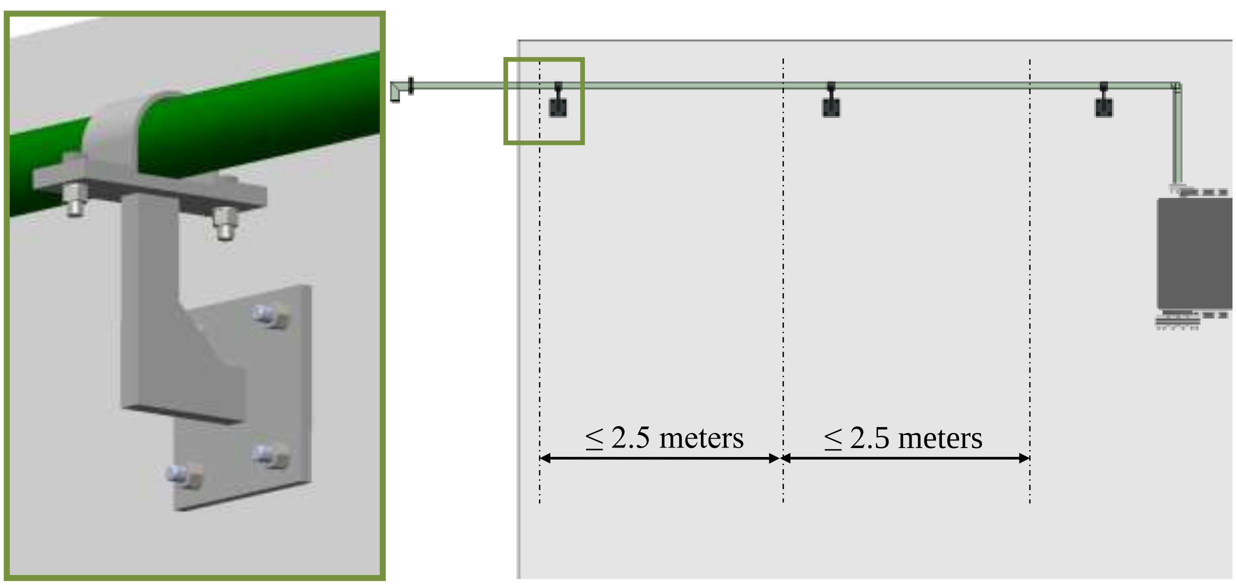


Figure 117: Explosive Gas Evacuation Pipe Support Example every 2.5 meters

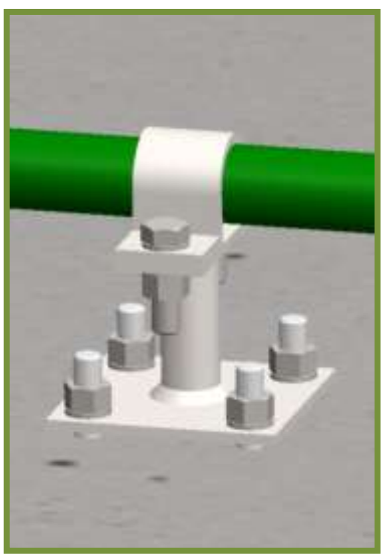
9.5.4 INERT GAS INJECTION PIPE SUPPORTS

The IGIP is routed from the TP Cabinet to the Transformer, OLTC (if applicable), and OCB (if applicable). The IGIP should be routed from the TP Cabinet with DN25 (1-inch) Stainless Steel piping. The IGIP support and clamp are recommended to be positioned so that the span between each is no more than 2.5 meters (8.2 ft) and as necessary. The IGIP support shall properly support and secure the piping from any type of movement. Below are some examples of the supports that may be found for the IGIP.

Support and clamp attached to the ground

Support and clamp when firewall exist

Figure 118: Inert Gas Injection Pipe Support Example



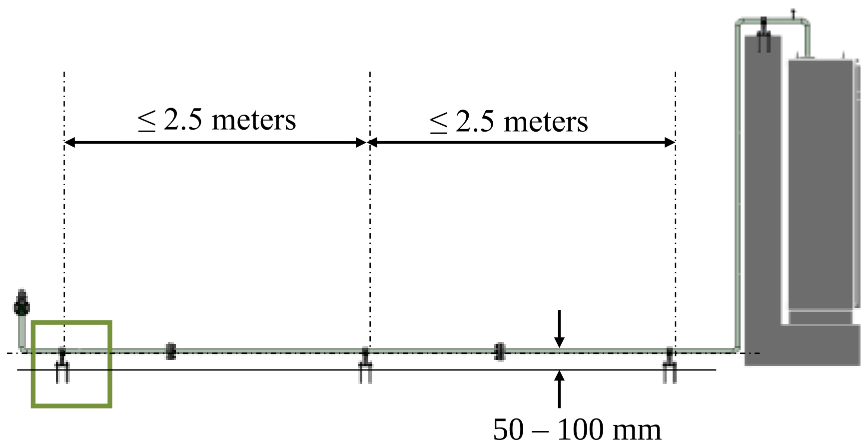
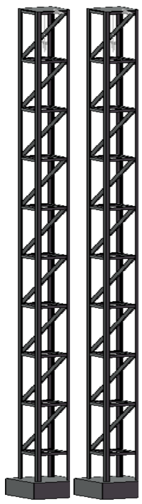


Figure 119: Inert Gas Injection Pipe Support Example every 2.5 meters

9.5.5 ELEVATED OIL-GAS SEPARATION TANK SUPPORTS

The EOGST is to be properly supported according to size and weight. The bottom of the EOGST is to be located 100 mm (4-inches) above the highest point of the transformer conservator. Below are some examples of EOGST supports.



Two self standing structure supports

Support to be attached to the transformer

Support to be attached to the transformer firewall

Figure 120: EGOST Support

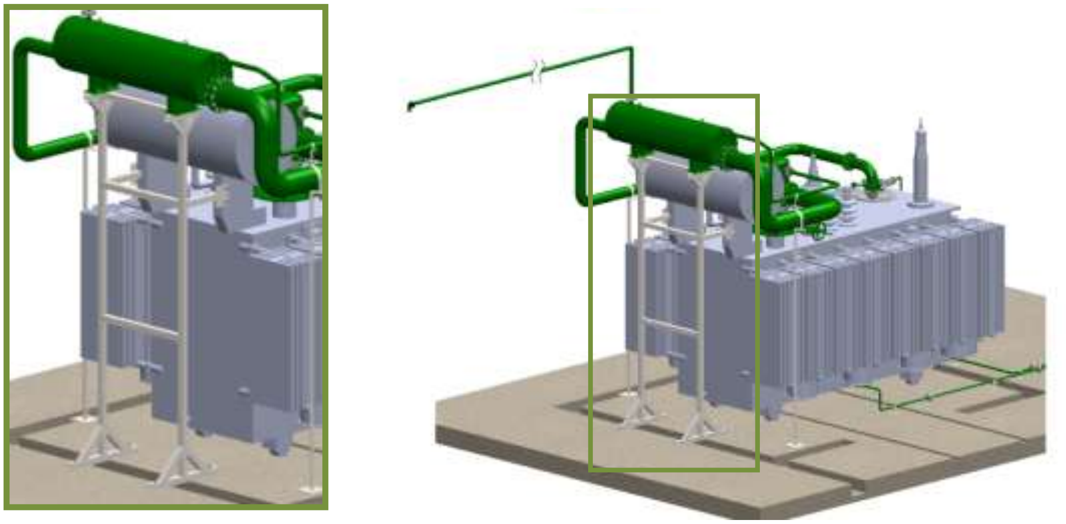


Figure 121: EOGST support attached to the transformer

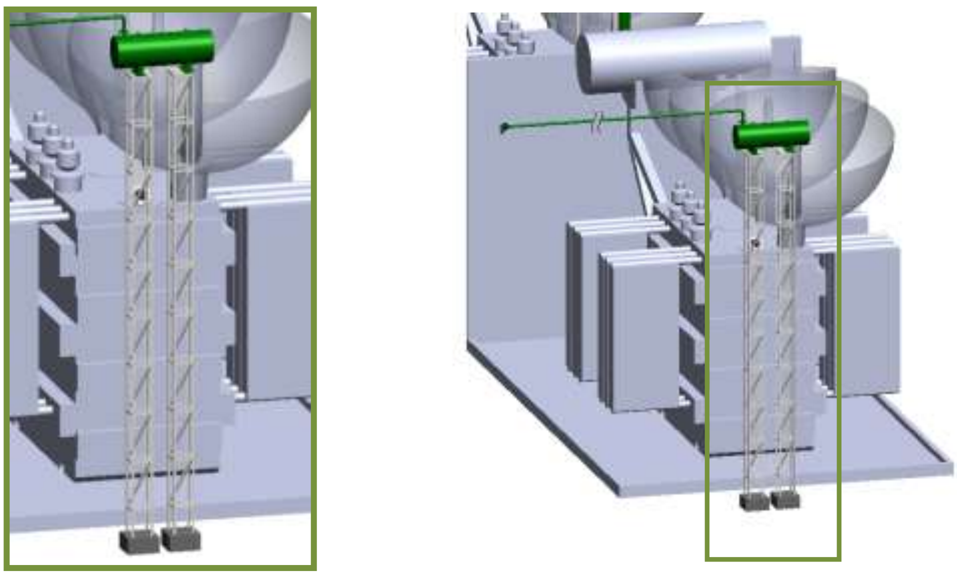


Figure 122: EOGST two structure support

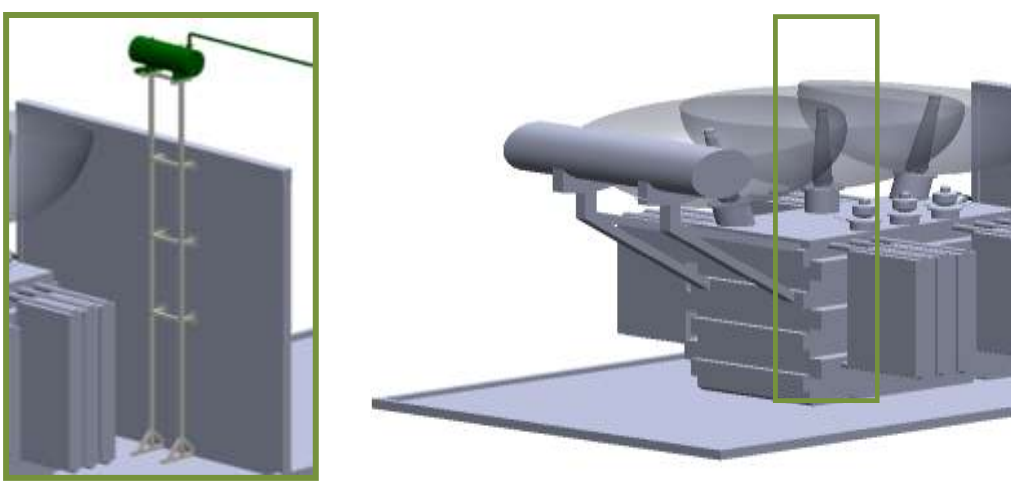
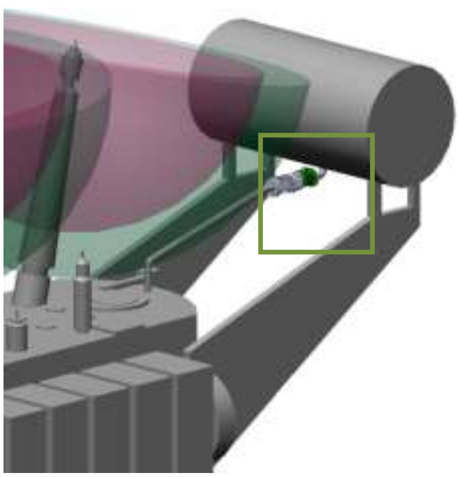


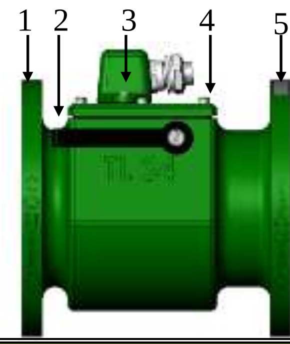
Figure 123: EOGST support attached to the firewall

10 OPTIONS

10.1 CONSERVATOR SHUTTER

The Conservator Shutter (2 or 3 inch) will quickly and effectively isolate the oil in the conservator tank, as soon as it detects abnormal high oil flow. This rapid oil flow may be caused by a transformer tank rupture (in the event of tank explosion), pipe or radiator rupture, etc. It is designed to permit a residual oil flow to the transformer, allowing the conservator tank to keep the transformer oil at its correct operating level. The Conservator Shutter is self contained and entirely mechanical in operation, which makes it very reliable. It is insensitive to shock waves and vibration (which may be generated by the transformer).





NO.	DESCRIPTION
1	Adaptation Flange for Conservator Tank
2	Conservator Shutter Handle
3	Terminal Cover for Electrical Connections
4	Conservator Shutter Main Body
5	Adaptation Flange for Transformer Tank

Figure 124: Conservator Shutter

10.2 DOUBLE FAILURE PROTECTION

Double Failure Protection is an option offered to clients in which the transformer DS is oversized. Assuming that the Electrical Protection failed, the transformer would not be tripped resulting in additional possible electrical arcs occurring inside the transformer. For this particular reason the transformer DS is oversized allowing the depressurization of the transformer while the transformer is still being energized.

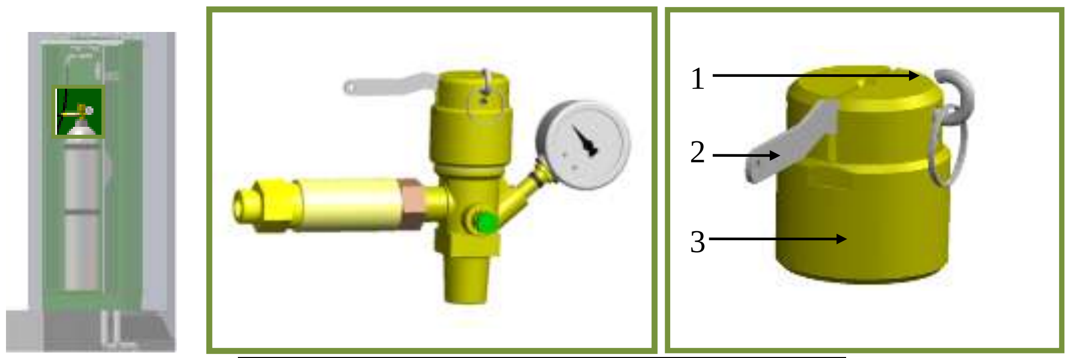
Generation, Transmission and Distribution Transformer Power, MVA	Depressurization Set Size	Double Failure Protection Sizing (Option)
0.1 MVA < TP ≤ 1 MVA	DN 100 / 4-inch	DN 125 / 5-inch
1 MVA < TP ≤ 4 MVA	DN 125 / 5-inch	DN 150 / 6-inch
4 MVA < TP ≤ 15 MVA	DN 150 / 6-inch	DN 200 / 8-inch
15 MVA < TP ≤ 100 MVA	DN 200 / 8-inch	DN 250 / 10-inch
100 MVA < TP ≤ 300 MVA	DN 250 / 10-inch	DN 300 / 12-inch
300 MVA < TP ≤ 500 MVA	DN 300 / 12-inch	2 x DN 300 / 2 x 12-inch
500 MVA < TP	2 x DN 300 / 2 x 12-inch	*
*To be studied by SERGI France Project Department		

Table 4: Standard Depressurization Set Size for Transformers

10.3 TRIGGER FOR INERT GAS CYLINDER

10.3.1 MANUAL TRIGGER FOR INERT GAS CYLINDER

This option is often ordered by clients who want to inject inert gas directly from the TP Cabinet. Manual Injection can be done by removing the safety pin and pulling down the lever. The IGIS injects inert gas into the bottom of the transformer, OLTC, and OCB. The figure below shows the components of the Manual Trigger for Inert Gas Cylinder.

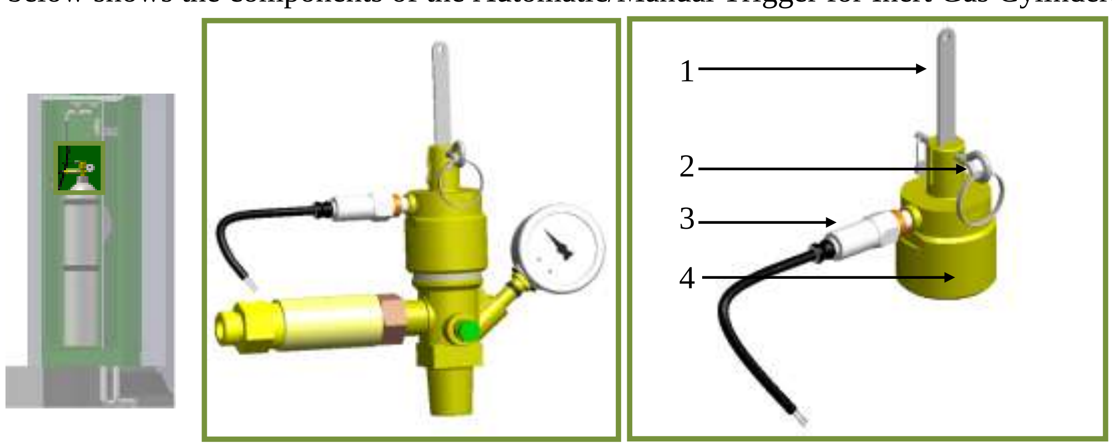


No.	Item Description
1	Safety Pin
2	Lever for Manual Activation
3	Manual Trigger for Inert Gas Cylinder

Figure 125: Manual Trigger for Inert Gas Cylinder

10.3.2 AUTOMATIC/MANUAL TRIGGER FOR INERT GAS CYLINDER

This feature allows the inert gas to be automatically activated once two conditions have been confirmed. The Manual Injection option is to inject inert gas directly from the TP Cabinet. Manual Injection can be done by removing the safety pin and pressing down the lever. The figure below shows the components of the Automatic/Manual Trigger for Inert Gas Cylinder.



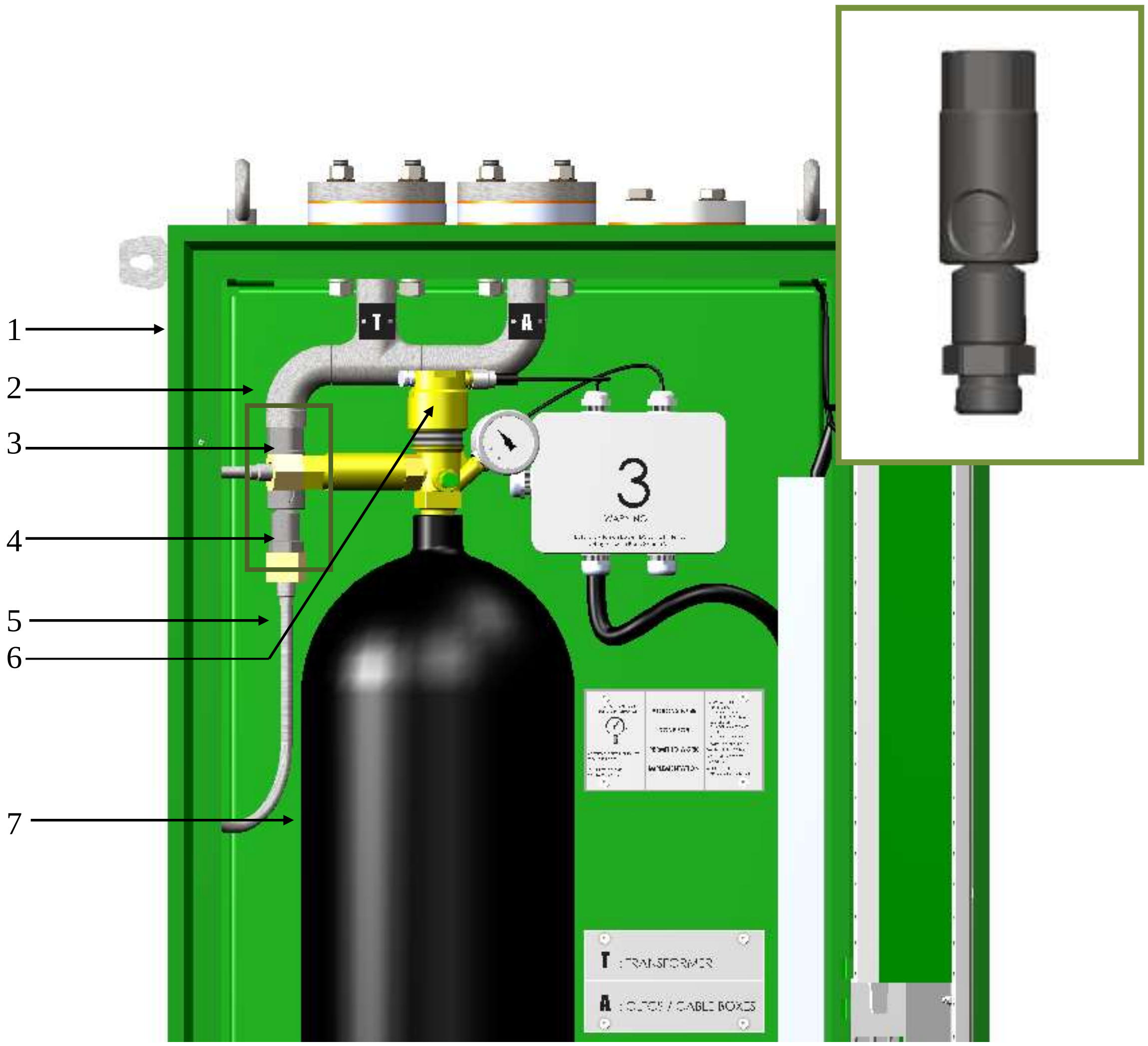
No.	Item Description
1	Lever for Manual Activation
2	Electrical Actuator
3	Safety Pin
4	Automatic/Manual Trigger for Inert Gas Cylinder

Figure 126: Automatic/Manual Trigger for Inert Gas Cylinder

10.3.3 QUICK CONNECTOR

The Inert Gas Cylinder is kept disconnected from the IGIP during standby mode. When the injection of the inert gas is required, it is necessary to:

1. Connect the Inert Gas Cylinder to the IGIP with the Quick Connector
2. Trigger the Inert Gas Cylinder:
    a. Manually confirm the Trigger at the TP Control Box
    (possible with Automatic or Automatic/Manual Trigger for Inert Gas Cylinder).
    b. Manually Trigger the Inert Gas Cylinder at the TP Cabinet;
    (possible with the Manual or Automatic/Manual Trigger for Inert Gas Cylinder).



No.	Item Description
1	TP Cabinet
2	Manifold
3	Quick Connector Socket
4	Quick Connector Plug
5	Flexible Hose
6	Trigger for Inert Gas Cylinder
7	Inert Gas Cylinder

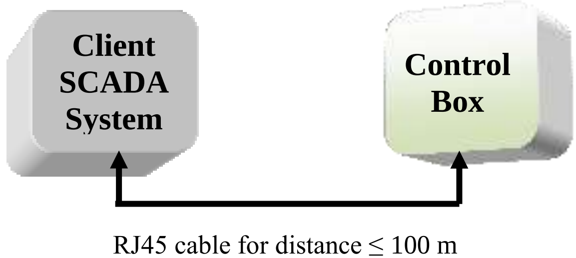
Figure 127: Quick Connector

10.4 ETHERNET CONNECTION TO SCADA

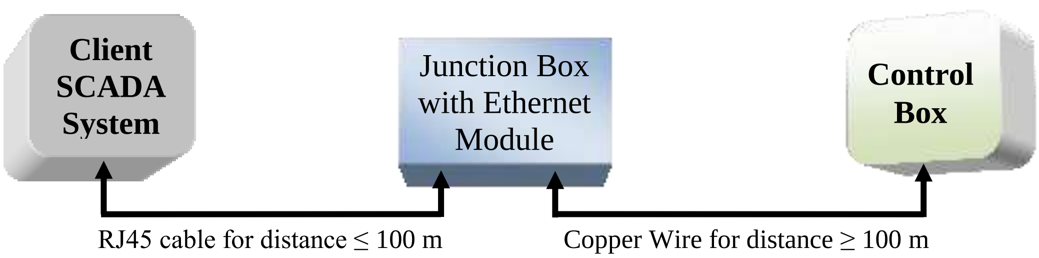
The Ethernet device will permit the collection of information from the TP components and to communicate with the SCADA system. The connection method of the Ethernet device will be of spring-cage terminals. It is suitable for operating between 0° and 55° C (32° F to 131° F).

The Ethernet device transmission can be performed in the following ways:

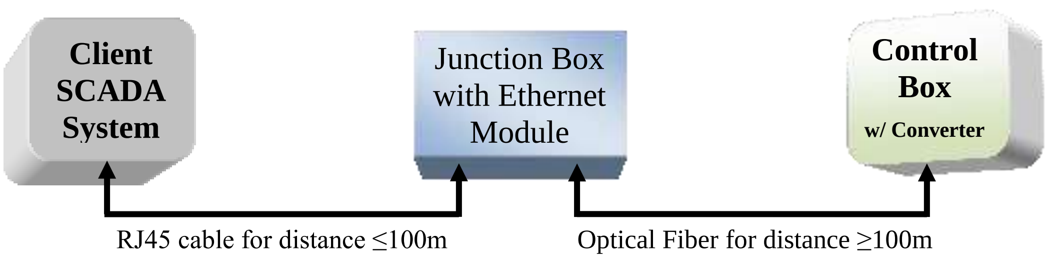
1. Utilizing RJ45 Cable: The transmission distance (total cable length) of the data using the Ethernet device from the Control Box to the SCADA system should be less than or equal to 100 m (328 ft).



2. **(A)**Utilizing a Junction Box: If the transmission distance (total cable length) of the data is greater than 100 m (328 ft) between the Ethernet device from the Control Box to the SCADA system, a Junction Box will be utilized. The distance between the Junction Box and the SCADA system should be less than or equal to 100 m (328ft).



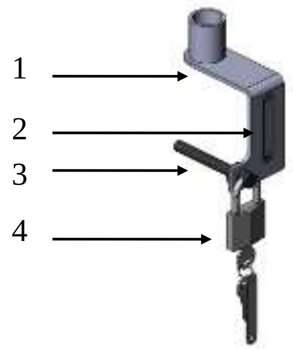
2. **(B)**Utilizing Fiber Optic: If the transmission distance (total cable length) of the data is greater than 100 m (328 ft) between the Ethernet device from the Control Box to the SCADA system, a Junction Box will be utilized. The distance between the Junction Box and the SCADA system should be less than or equal to 100 m (328ft).



The Ethernet device can work with two different protocols: Modbus/TCP or OPC. Only for the Modulus OPC a server is required, which has to be installed on the client's system to communicate with the Ethernet module.

10.5 ISOLATION VALVE PADLOCK

The Isolation Valve Lock Set is a device that may be requested by the client for locking the Isolation Valve in an Open/Closed position.



NO.	DESCRIPTION
1	Isolation Valve Lock
2	Isolation Valve Lock ID Plate
3	Isolation Valve Lock Pin
4	Padlock

Figure 128: Isolation Valve Lock Set

10.6 TP CABINET

10.6.1 LIGHT SET FOR TP CABINET

The Light Set for TP Cabinet will allow lighting inside the TP Cabinet while making an inspection of the TP Cabinet and Inert Gas Cylinder pressure.

10.6.2 TP CABINET AUDIBLE ALARM SET

Once the inert gas has been initiated, the Audible Alarm can be utilized to warn the personnel onsite. The alarm may be positioned anywhere around the transformer to warn the personnel that the TP has been activated.

10.6.3 HYGROSTAT

A Hygrostat should be included as part of the Inert Gas Set for those areas which have high levels of humidity; specifically above 60% of relative humidity. It will allow maintaining the TP Cabinet subcomponents out of oxidation.

10.6.4 IGIP VALVES

There exist three different valves which isolate the transformer from the IGIP during maintenance operations which are the following:

- 1” Electro Valve (position indicated in the Control Box)
- 1” Manual Ball Valve
- 1” Ball Valve with position indicator (position indicated in the Control Box)

10.6.5 AUTONOMOUS DRY BATTERY

The Autonomous Dry Battery assures an independent power supply. In case of insufficient battery load, a signal is sent to the control room, triggering an alarm.

11 ITEMS NOT SUPPLIED

The following items are not provided:

NO.	ITEM
1	Buchholz Relay
2	The electrical protection devices such as: differential relay, over current relay, etc.
3	PRVs unless requested specifically.
4	IGIV (1-inch valves used for the injection of inert gas) unless the ones specified.
5	LHD mounting bracket (support).
6	Adaptation flanges for the transformer, OLTC, and OCB/OBCB covers.
7	All wiring, connections, and supports between Cabinet and the Control Box.
8	All wiring, connections, and supports between Control Box and DC voltage supply.
9	All wiring, connections, and supports between Control Box and the transformer connection box.
10	ODP and IGIP supports.
11	Wall and concrete securing bolts for mounting Cabinet and Control Box.
12	DS mounting bracket and support.
13	Cable for the connection of the RD to the transformer connection box
14	Cable for the connection of the IV to the transformer connection box. This cable must be fire-rated.
15	OGST (unless ordered as an extra).
16	All IGIP, EGEP, GEP and ODP (unless ordered as an extra).
17	Any parts (such as T-pieces and valves) required for the adaptation of the inert gas injection piping onto existing valves.
18	Any parts required for the adaptation of the DS onto flanges that do not fit the supplied flanges.
19	Earthing for the Control Box and the TP Cabinet
20	AC supply for the TP Cabinet
21	DC or AC supply for the Control Box.
** The list is subject to change according to the TP evolution and TP configuration.*	

Table 5: Items not considered in the TP Scope of Supply

The piping used for the installation of the TP, should be selected in accordance to Technical Specification: “Pipes and Attachment Components”, otherwise will withdraw its warranty.

12 ABREVIATIONS

AIS	Air Isolation Shutter
DC	Decompression Chamber
DS	Depressurization Set
EA	Electrical Actuator
EGEP	Explosive Gas Evacuation Pipe
EGES	Explosive Gas Evacuation Set
EOGST	Elevated Oil-Gas Separation Tank
EV	Electro Valve
GEP	Gas Evacuation Pipe
HDS	Horizontal Depressurization Set
IFS	Insulating Flange Set
IGIP	Inert Gas Injection Pipe
IGIS	Inert Gas Injection Set
IGIV	Inert Gas Injection Valve
IV	Isolation Valve
LHD	Linear Heat Detector
NRV	Non-Return Valve
OBCB	Oil Bushing Cable Box
OCB	Oil Cable Box
ODP	Oil Drain Pipe
OGST	Oil-Gas Separation Tank
OLTC	On Load Tap Changer
PRV	Pressure Relief Valve
RD	Rupture Disk
SA	Shock Absorber
SOGST	Sliced Oil-Gas Separation Tank
TP	TRANSFORMER PROTECTOR
VDS	Vertical Depressurization Set
WOGST	Wall mounted Oil-Gas Separation Tank
45°DS	45-Degree Depressurization Set

13 GLOSSARY

Adaptation Piece: The Adaptation Piece is a pipe and flange that are installed on the transformer, OLTC, and OCB/OBCB for the installation of the Depressurization Set. The Adaptation Piece is a very critical element of the TP installation.

Air Isolation Shutter: The AIS is a check valve which is used to evacuate all the explosive gases collected after the activation of the TP. The AIS will only allow the explosive gases to evacuate the transformer, DS, piping, and OGST while not permitting air to come into contact with any explosive gases found in the system.

Control Box: The Control Box defines the TP operation logic.

Decompression Chamber: The Decompression Chamber will allow the pressure reduction eliminating the wave of pressure generated by the dynamic pressure inside the transformer in the case of an event.

Depressurization Set: The DS is attached to the transformer, OLTC, and OCB/OBCB to allow the depressurization in the case of an internal fault. The DS can be supplied in three different configurations (VDS, 45°DS, and HDS) for the transformer, and can also be supplied for the OLTC (internal and external) and/or OCB/OBCB. The DS is made of several different components such as the following: Isolation Valve, Shock Absorber, Rupture Disk, and Decompression Chamber.

Electrical Actuator: The Electrical Actuator is a pyrotechnic device which is activated by a short circuit controlled by the Control Box logic. Its activation is done once several states are confirmed in the Control Box. Once the Electrical Actuator is activated, it has to be replaced.

Electrical Protection: The Electrical Protection Signals are four signals which are the following: Buchholz Relay, Differential Relay, Earth Fault Protection Relay, and Over-Current Relay. The TP logic functions with the input of the Electrical Protection signals.

Electro Valve: The Electro Valve consists of allowing or blocking the passage of a fluid or gas. The Electro Valve operating time (0° - 90°) is 6 seconds, and it has a weight of 7 kgs (15.5 lbs). It should be installed as per space available.

Elevated Oil-Gas Separation Tank: The EOGST is an OGST option with a minimum volume of 0.5 m^3 (132 gallons). The EOGST is a cylindrical compartment design and mounted with a minimum of 100 mm (4-inches) above the transformer conservator.

Explosive Gas Evacuation Pipe: The EGEP will allow the explosive gases to exit from the entire system to a safe area away from the transformer and all surrounding equipment. The EGEP is routed from the OGST to a selected area where the explosive gases could be ejected to the environment without damaging any equipment or hurting any plant personnel.

External OLTC Depressurization Set: The External OLTC DS is an OLTC DS that is installed on the OLTC cover. The DS consists of an ODP connection which is routed to the main ODP that comes from the transformer DS. The External OLTC DS components are: Isolation Valve, Shock Absorber, Rupture Disk, and Decompression Chamber.

Gas Evacuation Pipe: The GEP will allow evacuation of the explosive gases and inert gas after TP activation. The GEP configuration is installed based on the TP type (VDS or HDS).

Horizontal Depressurization Set: The HDS is a transformer DS that is installed on the transformer wall and must be supported. The DS consists of an ODP connection which is routed to the OGST. The HDS components are: Isolation Valve, Shock Absorber, Rupture Disk, and Decompression Chamber. The HDS requires a GEP kit to be installed on the transformer conservator piping between the Buchholz and the conservator to allow explosive gases to evacuate from the transformer.

Inert Gas Injection Pipe: The IGIP will allow the injection of inert gas into the transformer from the TP Cabinet. The IGIP is to be routed from the TP Cabinet to the transformer, OLTC, and OCB. The IGIP will be full of transformer oil while it is in stand-by mode. During an activation inert gas will be injected through the IGIP at 1 bar into the bottom of the transformer, OLTC (if applies), and OCB (if applies).

Internal OLTC Depressurization Set: The Internal OLTC DS is installed on the OLTC cover. The DS consists of an ODP connection which is routed to the main ODP that comes from the transformer DS. The Internal OLTC DS components are: Rupture Disk and Decompression Chamber.

Isolation Valve: The purpose of Isolation Valve is to isolate the TP from the transformer during installation and maintenance phases.

Linear Heat Detector: The LHD Set is installed on the transformer cover to detect external heat excess. A signal will be received in the Control Box warning that an LHD event has occurred. The LHD Set will aim to confirm along with the electrical protections to inject inert gas into the transformer to keep the transformer interior under secure conditions.

Non-Return Valve: The NRV prevents the transformer from draining if the IGIP was to be broken or accidently damaged. The NRV should be installed on all of the IGIP connections (transformer, Internal OLTC, External OLTC, and OCB). The NRV should be installed in close proximity to the transformer, OLTC, and OCB IGIP valve.

Oil Bushing Cable Box Depressurization Set: The OBCB DS is a DS that is installed on the OBCB wall. The DS consists of an ODP connection which is routed to the main ODP that comes from the transformer DS. The OBCB DS components are: Isolation Valve, Shock Absorber and Rupture Disk.

Oil Cable Box Depressurization Set: The OCB DS is a DS that is installed on the OCB wall. The DS consists of an ODP connection which is routed to the main ODP that comes from the transformer DS. The OCB DS components are: Isolation Valve, Shock Absorber and Rupture Disk.

Oil Drain Pipe: The ODP will allow the evacuation of explosive gases and oil during the TP activation. The ODP takes into account the transformer, OLTC, and OCB/OBCB drain connections. The ODP will be routed connecting the Decompression Chamber with the OGST.

Oil-Gas Separation Tank: The OGST is a tank where explosive gases and oil will be expelled when the TP is activated. The OGST geometry with a volume of 0.5m^3 will depend on the configuration of the proposed OGST (SOGST, WOGST, or EOGST).

Rupture Disk: The Rupture Disk is a component that is installed on all the different types of Depressurization Sets. The Rupture Disk is calibrated to open at a specific pressure set point according to the transformer characteristics. When the Rupture Disk is opened an electric signal given by one or two Burst Indicators will send the open Rupture Disk information to the Control Box.

Safety Relief Valve: The SRV prevents the over pressurizing of the IGIP. The SRV has an opening set point of 3.5 bars (50 psi).

Shock Absorber: The purpose of the Shock Absorber is to reduce the propagation waves generated during the TP Depressurization Process.

Slice Oil-Gas Separation Tank: The SOGST is an OGST option with a minimum volume of 0.5 m^3 (132 gallons). The transformer manufacturer will construct a reserved compartment of the transformer conservator for the SOGST.

TP Cabinet: The TP utilizes the inert gas to evacuate all explosive gases generated and stabilize the transformer to a safe condition once the depressurization process has occurred. The inert gas is kept in a cylinder of up to 200 bar (2900 psi) inside the TP Cabinet and is properly secure under a controlled temperature of 15°C (59°F).

Transformer Protector: The TP depressurizes transformer within milliseconds avoiding explosion and subsequent fire. During a transformer short-circuit the TP is activated within milliseconds by the first dynamic pressure peak of the shock wave, avoiding transformer explosions before static pressure increases. The TP is a concept that can be applied to all transformers from 0.1 to 1000 and larger MVA power rating.

Vertical Depressurization Set: The VDS is a transformer DS that is installed on the transformer cover. The DS consists of a GEP and ODP connection which are routed to the OGST. The VDS components are: Isolation Valve, Shock Absorber, Rupture Disk, and Decompression Chamber.

Wall mounted Oil-Gas Separation Tank: The WOGST is an OGST option with a minimum volume of 0.5 m^3 (132 gallons). The WOGST will be mounted on the transformer firewall at least 100 mm (4-inches) above the transformer conservator.

45° Depressurization Set: The 45°DS is a transformer DS that is installed on the transformer cover and must be supported. The DS consists of an ODP connection which is routed to the OGST. The 45°DS components are: Isolation Valve, Shock Absorber, Rupture Disk, and Decompression Chamber.