

OWNER

Hazardous Area Classification

API RP 500 Class I, Division 1 and Division 2



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1. INTRODUCTION

This report classifies the hazardous (classified) locations at the in accordance with API RP 500, using the Class I, Division 1 and Division 2 system. The classification sets the type of electrical equipment, the wiring methods and the conduit seals that NFPA 70 (the National Electrical Code, NEC) Articles 500 and 501 require at each location, and it confirms that the equipment that cannot be rated for a classified location is placed outside every classified area.

The scope covers the fenced station between insulating joints IJ-101 and IJ-102: the inlet and pig receiver, the filter separator, the fuel gas skid, the meter skid, the analyzer shelter B-101, the line heater, the control valve and overpressure protection station, the vent stack, the liquids tank T-101 with its truck loadout, the control and electrical building B-102 and the standby generator G-101. Every release source is identified, the RP 500 figure that applies to it is named, and the extent adopted is stated with its reason. The report also assesses the ventilation of B-101 and derives the equipment and wiring requirements that follow from the classification.

The report excludes the tap valve and the receiving pipeline operator's facilities north of the fence, which the receiving pipeline operator classifies, and the upstream lateral south of IJ-101. Fire and gas detection coverage is addressed in SAF-RPT-003, Fire and Gas Detection. The classification plan, ELE-DWG-002, is reproduced in Section 6.

2. REFERENCES

1. API RP 500, 3rd Edition, Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2.
2. NFPA 70, National Electrical Code, 2023 Edition, Articles 500 and 501.
3. NFPA 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, 2021 Edition.
4. NFPA 30, Flammable and Combustible Liquids Code; NFPA 37, Installation and Use of Stationary Combustion Engines and Gas Turbines; NFPA 54, National Fuel Gas Code.
5. API RP 540, Electrical Installations in Petroleum Processing Plants.
6. GEN-DB-001, Basis of Design; GEN-RPT-002, Design Decisions Register.
7. MEC-DWG-001, Plot Plan, and its piping model (equipment footprints, roads and pipe routes).
8. PRO-CAL-007, Pressure Relief Devices and Tank Venting.
9. MEA-CAL-004, Sampling System; SAF-RPT-003, Fire and Gas Detection.
10. ELE-CAL-001, Electrical Load List and Load Analysis; ELE-CAL-007, Lighting Design.
11. ELE-DWG-002, Hazardous Area Classification Plan.



3. DESIGN BASIS

3.1. DESIGN INPUTS

The inputs in Table 3-1 govern the classification. Equipment positions and footprints are taken from the plot plan MEC-DWG-001, which governs the station layout; heights above grade are taken from the piping model elevations where it gives them, and are otherwise assumed as noted.

Table 3-1: Design Inputs

Input	Value	Source
Process fluid	Dry, sweet pipeline-quality natural gas	GEN-DB-001
Relative density (design, lean, rich)	0.638 / 0.593 / 0.680	GERG-2008 property model, GEN-DB-001 compositions
Liquids	Condensate and water at the V-101 sump, PR-101 and T-101	GEN-DB-001
Station layout	Equipment footprints, roads and pipe routes	MEC-DWG-001
Local grade	EL 1,152.0 ft (pipe centerline EL 1,154.5 ft on 30 in supports)	Assumed from MEC-DWG-001
PR-101 and V-101 closure centerlines	4.1 ft and 6.5 ft above grade	MEC-DWG-001 elevations
VS-101 outlet	25 ft above grade	GEN-DB-001
PSV-161 discharge	Piped to the vent header through 2"-V-1077-S1; no local vent	PRO-CAL-007
T-101	9.5 ft OD x 8 ft shell; PVRV-193 / FA-193 NPS 6 and EV-193 16 in on the roof	MEC-DS-004, PRO-CAL-007
T-101 containment wall height	3 ft	Assumed; civil to confirm
Analyzer vent header outlet	13 ft above grade, 3 ft above the B-101 roof	Assumed; instrumentation to confirm
B-101 shelter	10 ft x 12 ft x 9 ft clear; EF-101A/B 250 cfm each, duty and standby	SAF-RPT-003
Analyzer sample supply	25 psig at RO-141A (1/32 in); PSV-141B set 50 psig	MEA-CAL-004, PRO-CAL-007
E-161 fuel gas preheater	5 kW, explosion-proof, on 2"-F-1050 upstream of PCV-161, outlet 105 °F	GEN-RPT-002

3.2. ASSUMPTIONS

1. Heights not given by the piping model are as stated in Table 3-1. The envelopes move with the equipment; they will be rechecked against vendor drawings before the next issue. *Verification required (HOLD H-15).*
2. RP 500 figures are cited by title. Figure and clause numbers will be confirmed against the edition adopted for the project before the next issue.
3. The H-101 burner fuel train is arranged by the heater vendor as described in Section 6.5. *Verification required (HOLD H-15).*
4. The station is unmanned and visited by qualified operators; access is controlled by the station fence.



4. METHOD

TORUS first determined the properties of the gas that govern classification: whether it is lighter or heavier than air, its lower flammable limit (LFL), its lowest autoignition temperature (AIT), which fixes the temperature class of equipment, and its NEC material group. Every point where gas or liquid can be released to atmosphere was then identified from the plot plan and the P&IDs, and each was matched to the RP 500 figure for that kind of source and ventilation. All outdoor equipment, including the meter skid under its roof-only canopy, is in an adequately ventilated nonenclosed area. B-101 is an enclosed, mechanically ventilated area.

For flanges, valve stems and instrument connections in adequately ventilated nonenclosed areas, RP 500 permits a Division 2 extent of 3 ft around each fitting. TORUS did not use fitting-by-fitting envelopes. Each equipment and piping group is instead enclosed in one Division 2 envelope that extends 10 ft beyond the group footprint and to 10 ft above the highest source. This gives simple outlines that a contractor can set out on site, and it means that an added instrument tap or drain valve during construction does not change the classification. The cost of the larger envelope is small, because all equipment in the process area is Division 2 rated in any case.

Finally, TORUS checked that the equipment that is an ignition source in normal operation, namely B-102 and its contents, the G-101 engine, XF-101 and the H-101 burner, lies outside every envelope, and that B-102 is at least 50 ft from every release source as the Basis of Design requires.

5. GAS PROPERTIES

Table 5-1 lists the component flammability data used. The LFL of each gas case was calculated with Le Chatelier's rule over the combustible components:

$$LFL_c = \frac{1}{\sum_i y_i / LFL_i}$$

where y_i is the mole fraction of component i normalized to the combustible fraction f_c . Crediting the nitrogen and carbon dioxide as diluents gives the mixture value $LFL_m = LFL_c / f_c$.

Table 5-1: Component Flammability Data

Component	Design, mol %	Lean, mol %	Rich, mol %	LFL, vol %	AIT, °C
Methane	88.50	94.00	83.60	5.0	600
Ethane	6.00	3.00	8.50	3.0	472
Propane	2.20	0.60	3.60	2.1	450
i-Butane	0.40	0.10	0.70	1.8	460
n-Butane	0.50	0.10	0.90	1.8	288
i-Pentane	0.12	0.03	0.25	1.4	420
n-Pentane	0.10	0.02	0.20	1.5	243
n-Hexane	0.10	0.02	0.15	1.2	225

Note 1: LFL and AIT values from NFPA 497 and US Bureau of Mines Bulletin 627. All components are NEC Group D.

For the design gas:

$$LFL_c = \frac{1}{0.2194} = 4.56 \%, \quad LFL_m = \frac{4.56}{0.9792} = 4.65 \%$$

Table 5-2 gives the results for all three cases.

Table 5-2: Flammability and Density of the Station Gas

Case	Molecular weight	Relative density	Combustible fraction	LFL, combustibles, vol %	LFL, mixture, vol %
Design	18.46	0.638	0.979	4.56	4.65
Lean	17.16	0.593	0.979	4.83	4.94
Rich	19.69	0.680	0.979	4.33	4.43

The gas is lighter than air in every case. RP 500 treats a gas with a relative density above 0.75 as heavier than air; the rich case, at 0.680, is well below that, so the lighter-than-air figures apply to gas sources. Liquids collected at V-101, PR-101 and T-101 can give off condensate vapor that is heavier than air, so the liquid sources are classified with the heavier-than-air extents near grade.

For the ventilation and dilution checks, TORUS used the lowest LFL of the three cases without credit for the inert components, 4.33 vol % (rich case), so that 25 % of the LFL is 1.08 vol %. The inert credit is worth only about 2 % and taking the lower value keeps this report consistent with SAF-RPT-003.

The lowest autoignition temperature of any component present is 225 °C, for n-hexane. NEC 500.8 requires the marked surface temperature of equipment to stay below the AIT, so temperature class T3 (200 °C maximum) is the minimum for equipment in any classified area of this station. T4 (135 °C) will be specified where it is commercially available, since it gives margin against the heavier hydrocarbons in the rich gas.



6. RELEASE SOURCES AND CLASSIFICATION

Table 6-1 lists every classified envelope, and the sections that follow give the reason for each extent. The envelopes are shown to scale on the classification plan at the end of this section.

Table 6-1: Classified Envelopes

ID	Source	Division	Extent
Z-01	Inlet group: PR-101 barrel valves, kicker 1101, equalizing 1102, BDV-102, PT-102A, SDV-101 and bypass 1103, V-101 flanges and PSV-101 inlet, PDIT-103, LT-104, SDV-106, LCV-104 / RO-104, BDV-181	2	10 ft beyond the group footprint X 24 to 94 ft, Y 25 to 42 ft; grade to 20 ft
Z-02	FG-101 fuel gas skid and 2"-F-1050: HV-161A/B, E-161 preheater flanges, filter, PCV-161/162, FT-163, SDV-165, PSV-161 body (discharge piped to header via 1077)	2	10 ft beyond the group footprint X 79 to 99 ft, Y 52 to 59 ft; grade to 18 ft
Z-03	SK-110 meter skid under canopy (roof only, open sides): MOV-111/112/115/121/122 stems and DBB bleeds (collector 1120), USM flanges, PT/TT-111/121, header 1010, SP-141 probe on 1020	2	10 ft beyond the group footprint X 60 to 108 ft, Y 89 to 116 ft; grade to 20 ft
Z-04	Control valve station: FCV-131/132 stems, HV-131A/B, HV-132A/B, 12 x 8 reducer flanges, ZT-131/132	2	10 ft beyond the group footprint X 139 to 161 ft, Y 84 to 96 ft; grade to 20 ft
Z-05	Outlet group: PT-133A/B/C, PT-134, TT-135, HV-133D, SDV-102 and bypass 1162, TSV-136, BDV-183, CKV-171, SDV-103 and bypass 1171, HV-172A, PT-172, TT-173	2	10 ft beyond the group footprint X 161 to 220 ft, Y 88 to 96 ft; grade to 20 ft
Z-06	H-101 process end and bypass: coil inlet / outlet flanges (Class 900), HV-158A/B/C, bypass 1021, BDV-182 on 1020, PSV-157 inlet, TT-151, TT-156	2	10 ft beyond the group footprint X 140 to 175 ft, Y 138 to 148 ft; grade to 20 ft
Z-07	T-101 tank connections: roof inlet N1 (1190), inlet manifold HV-191A/B, LT-191 nozzle, bottom drain 1192, LG-191A	2	10 ft beyond the group footprint X 25 to 37 ft, Y 80 to 105 ft; grade to 18 ft
Z-08	VS-101 outlet (all PSV, TSV and BDV discharges incl. PSV-161 via 1077)	1	5 ft radius about (40, 160) at 25.0 ft above grade
Z-09	VS-101 outlet	2	10 ft radius about (40, 160) at 25.0 ft above grade
Z-10	VS-101 base: 2 in drain valve with plug and portable collection pan	2	10 ft radius about (40, 160); grade to 3.0 ft

ID	Source	Division	Extent
Z-12	B-101 analyzer / GC / sampler vent header outlet above roof	1	5 ft radius about (120, 121) at 13.0 ft above grade
Z-13	B-101 analyzer vent header outlet	2	10 ft radius about (120, 121) at 13.0 ft above grade
Z-14	PR-101 quick-opening closure (opened for pig retrieval)	1	5 ft radius about (24, 40) at 4.1 ft above grade
Z-15	PR-101 closure	2	15 ft radius about (24, 40) at 4.1 ft above grade
Z-16	PR-101 closure, liquids / condensate at grade	2	25 ft radius about (24, 40); grade to 1.5 ft
Z-17	V-101 quick-opening closure, west end (opened for element change)	1	5 ft radius about (75, 40) at 6.5 ft above grade
Z-18	V-101 closure	2	15 ft radius about (75, 40) at 6.5 ft above grade
Z-19	V-101 closure, liquids at grade	2	25 ft radius about (75, 40); grade to 1.5 ft
Z-20	T-101 interior (vapor space)	1	4.75 ft radius about (30, 100); grade to 8.0 ft
Z-21	T-101 PVRV-193 / FA-193 NPS 6 breathing vent	1	5 ft radius about (30, 100) at 10.0 ft above grade
Z-22	T-101 PVRV-193 / FA-193 NPS 6 breathing vent	2	10 ft radius about (30, 100) at 10.0 ft above grade
Z-29	T-101 EV-193 16 in emergency vent (opens only on blow-by / fire)	1	5 ft radius about (32, 100) at 9.0 ft above grade
Z-30	T-101 EV-193 emergency vent	2	10 ft radius about (32, 100) at 9.0 ft above grade
Z-23	T-101 containment (heavier-than-air condensate vapor)	2	X 18 to 42 ft, Y 88 to 112 ft; grade to 3 ft
Z-24	T-101 truck loadout dry-break connection (line 1191)	1	3 ft radius about (30, 116) at 3.0 ft above grade
Z-25	T-101 truck loadout connection	2	10 ft radius about (30, 116) at 3.0 ft above grade
Z-26	T-101 truck loadout, liquids at grade	2	25 ft radius about (30, 116); grade to 1.5 ft



ID	Source	Division	Extent
Z-27	B-101 interior: analyzer tubing fittings, SDV-141 with RO, GC, SCS, SMP-146	2	X 112 to 124 ft, Y 113 to 123 ft; grade to 10 ft
Z-28	B-101 door, intake louver and exhaust fan outlets	2	3 ft beyond the group footprint X 112 to 124 ft, Y 113 to 123 ft; grade to 13 ft

Note 1: Coordinates are plant coordinates in feet from the southwest fence corner, X east, Y north. Heights are above local grade.

Table 6-2 names the RP 500 figure applied to each envelope.

Table 6-2: RP 500 Figure Applied to Each Envelope

RP 500 figure (by title)	Envelopes
Adequately ventilated nonenclosed area, lighter-than-air gas, process piping with valves, flanges and instrument connections	Z-01, Z-02, Z-03, Z-04, Z-05, Z-06
Atmospheric storage tank, flammable liquid, fixed roof with vent	Z-07, Z-20, Z-21, Z-22
Relief valve / vent discharging lighter-than-air gas to atmosphere	Z-08, Z-09, Z-12, Z-13, Z-29, Z-30
Drain valve / open liquid collection at grade (heavier-than-air vapor)	Z-10
Pig launcher / receiver and vessel quick-opening closure opened in normal operation	Z-14, Z-15, Z-16, Z-17, Z-18, Z-19
Diked / curbed area around a flammable liquid storage tank	Z-23
Tank truck loading / unloading connection (bottom or top loading)	Z-24, Z-25, Z-26
Adequately ventilated enclosed area containing lighter-than-air gas sources	Z-27
Openings of an adequately ventilated enclosed Division 2 area	Z-28

6.1. PROCESS EQUIPMENT GROUPS

Flanged joints, valve stem packing, instrument connections and small bleed and drain valves release gas only if a gasket or packing fails. They are Division 2 sources. The seven group envelopes Z-01 to Z-07 each extend 10 ft beyond the group footprint and from grade to 10 ft above the highest source, which is generally the PSV or instrument manifold at about 10 ft. The inlet group Z-01 takes in the pig receiver valves and kicker line, SDV-101 with its equalizing bypass, the V-101 flanges and PSV-101 inlet, and the V-101 liquid outlet valves SDV-106, LCV-104 and RO-104. The control valve group Z-04 covers the stem packing of FCV-131 and FCV-132. The outlet group Z-05 covers the overpressure protection transmitters, SDV-102, CKV-171, SDV-103, their equalizing bypasses and the vent and thermal relief valves between them.

The meter skid is under a canopy that has a roof and no walls. It remains an adequately ventilated nonenclosed area, because the roof does not restrict horizontal air movement, and it is classified with the same 10 ft group envelope, Z-03, which also covers the sample probe SP-141 on line 1020.

Welded piping between the groups, including the buried road crossings and the buried lines 1042, 1051 and 1052, is not a source. The monolithic insulating joints IJ-101 and IJ-102 are welded and are not sources.

6.2. VENT, RELIEF AND DRAIN POINTS

All relief valves (PSV-101, PSV-157, PSV-161), thermal relief valve TSV-136 and the manual blowdown valves discharge through the stainless steel vent header to VS-101, 25 ft above grade. The outlet is classified with the RP 500 relief vent figure: Division 1 within 5 ft and Division 2 from 5 ft to 10 ft (Z-08, Z-09). These envelopes do not reach grade. PSV-161 originally vented locally at the fuel gas skid; it now discharges to the header, so no local envelope is needed at FG-101.

Liquid that collects at the base of VS-101 is removed through a 2 in plugged drain valve into a portable pan, emptied by vacuum truck under a work permit. The release is abnormal and short, so it is Division 2, within 10 ft of the stack base and to 3 ft above grade (Z-10), sized for heavier-than-air condensate vapor at the pan.

The analyzer, chromatograph and sampler vents are manifolded and discharged through the B-101 roof at 13 ft. They release continuously at a low rate, so the outlet is Division 1 within 5 ft and Division 2 to 10 ft (Z-12, Z-13). No vent discharges inside B-101.

6.3. PIG RECEIVER AND FILTER SEPARATOR CLOSURES

The PR-101 quick-opening closure is opened at every pig retrieval, and the V-101 closure at every filter element change. Both are opened in normal operation, after depressuring and purging, with residual gas and condensate present. Each is classified Division 1 within 5 ft and Division 2 within 15 ft of the closure (Z-14, Z-15, Z-17, Z-18). Because condensate can drain from the barrel into the pan below the closure, a heavier-than-air Division 2 extent is added from grade to 18 in above grade within 25 ft of each closure (Z-16, Z-19).

6.4. LIQUIDS TANK T-101 AND TRUCK LOADOUT

T-101 is a 9.5 ft by 8 ft atmospheric tank at (30, 100) inside a 24 ft square containment. Its vapor space is Division 1 (Z-20); RP 500 has no Zone 0 category. The PVRV-193 and FA-193 breathing vent is Division 1 within 5 ft and Division 2 to 10 ft (Z-21, Z-22). The EV-193 emergency vent opens only on gas blow-by from V-101 or in a fire, and is classified in the same way as a relief outlet (Z-29, Z-30). The containment is Division 2 to the top of its wall because condensate vapor is heavier than air (Z-23), and the tank connections and inlet manifold are enclosed in the group envelope Z-07.

The truck loadout dry-break connection at (30, 116) is Division 1 within 3 ft and Division 2 within 10 ft, with the heavier-than-air Division 2 extent from grade to 18 in above grade within 25 ft (Z-24 to Z-26), per the RP 500 figure for tank truck loading.

6.5. LINE HEATER H-101

The process connections of H-101, the coil inlet and outlet flanges, the heater isolation and bypass valves, BDV-182 and the PSV-157 inlet, are grouped at and west of the west end of the heater. Their envelope Z-06 ends at X = 185 ft, 21 ft from the burner and firebox openings at the east end. The burner is an ignition source in normal operation and is not classified.

The burner fuel train (safety shutoff valves, TCV-152 and the fuel pressure switches) carries fuel gas already reduced by PCV-162 to low pressure. RP 500 recognizes that the fuel train at a fired heater need not be classified where its release potential is small, since a flame is already present. TORUS has adopted that treatment on three conditions, which the heater specification will carry: joints are welded or threaded and seal-welded; TCV-152 has low-emission packing tested to API 622 or ISO 15848; and the fuel-train stand is at least 5 ft from the firebox and air-inlet openings. The burner management panel CP-150 is unclassified.

6.6. FUEL GAS SKID AND PREHEATER E-161

The fuel gas skid FG-101 and the 2"-F-1050 supply line are enclosed in Z-02. The electric preheater E-161, at (88, 57), lies inside it. Its flanges are Division 2 sources, and the heater itself is electrical equipment in a Division 2 area. It shall be listed for Class I, Division 1 (flameproof) or Division 2, Group D, with its sheath temperature marked T3 or better and an independent high-limit cutout, so that no surface can reach the 225 °C autoignition temperature even if the temperature controller fails.

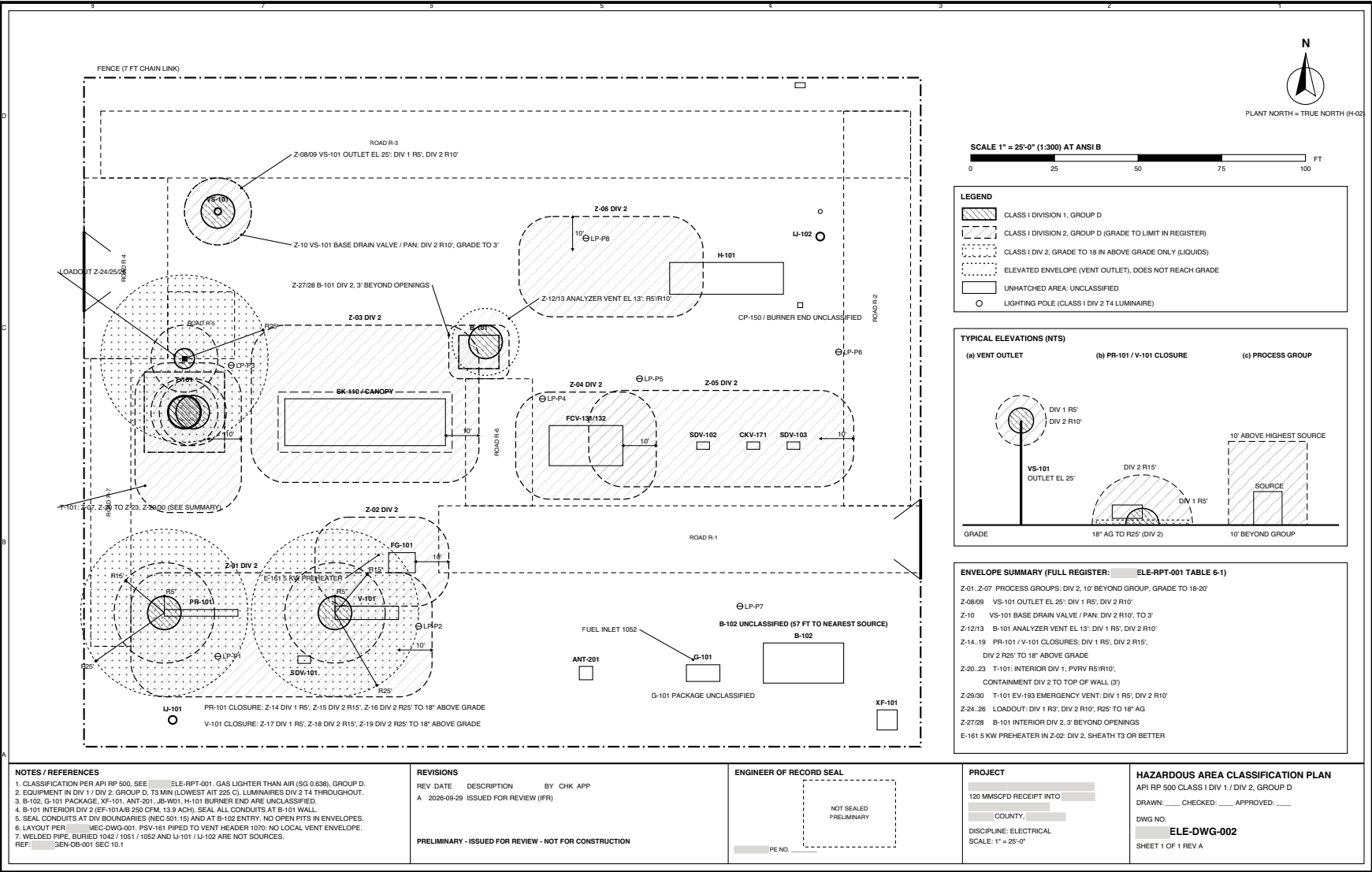
6.7. ANALYZER SHELTER B-101

B-101 contains Division 2 sources: tubing fittings, the analyzer sample systems and SDV-141. With adequate ventilation, demonstrated in Section 7, its interior is Division 2 (Z-27). The Division 2 area extends 3 ft beyond the door, the make-up louver and the fan outlets. TORUS applied the 3 ft all around the shelter (Z-28) rather than at each opening, so that later changes to door or louver positions do not affect the classification.

6.8. CLASSIFICATION PLAN

Figure 6-1 shows every envelope to scale on the station plan, with an elevation inset for the typical vent, closure and process group envelopes, and the lighting poles. The drawing is issued separately as ELE-DWG-002, Hazardous Area Classification Plan.

Figure 6-1. Hazardous Area Classification Plan, ELE-DWG-002



7. ANALYZER SHELTER VENTILATION

RP 500 treats an enclosed area as adequately ventilated when the ventilation prevents a vapor-air mixture above 25 % of the LFL from accumulating. It accepts mechanical ventilation of at least 1 cfm per square foot of floor area or 6 air changes per hour as meeting this, or a dilution calculation for the largest credible release. SAF-RPT-003 sets a higher minimum of 12 air changes per hour, which for B-101 is 216 cfm at the 9 ft clear height used here, and specifies two 250 cfm exhaust fans, EF-101A duty and EF-101B standby, drawing from high level with a low-level make-up louver.

The duty fan gives:

$$\frac{Q}{A_{\text{floor}}} = \frac{250}{120} = 2.08 \text{ cfm/ft}^2, \quad N = \frac{60 Q}{V} = \frac{60 \times 250}{1,080} = 13.9 \text{ air changes/h}$$

Both prescriptive rates are exceeded. The dilution check follows. All sample gas enters B-101 through restriction orifice RO-141A, a 1/32 in bore immediately downstream of SDV-141 at the shelter wall. A tubing break inside the shelter therefore cannot release more than the choked flow through RO-141A:

$$\dot{m} = C_d A \sqrt{\kappa P_1 \rho_1 \left(\frac{2}{\kappa + 1} \right)^{\frac{\kappa + 1}{\kappa - 1}}}$$

with $C_d = 0.80$ for the tubing-fitting orifice insert and the isentropic exponent κ taken from the GERG-2008 speed of sound. At the normal supply pressure of 25 psig and 60 °F, $\kappa = 1.281$ and $\rho_1 = 0.1303 \text{ lb/ft}^3$; the pressure ratio of 2.8 is well above critical, and the release is 1.56 lb/h, or 32 scf/h. The well-mixed concentration in the shelter is:

$$x = \frac{q_{\text{gas}}}{Q + q_{\text{gas}}} = \frac{0.557}{250 + 0.557} = 0.222 \text{ vol } \%$$

against the limit of 1.08 vol %. Table 7-1 extends the check to a failed-open probe regulator. PSV-141B, set at 50 psig on the regulator outlet outside the shelter, limits the pressure at RO-141A to 55 psig while it relieves. The last row shows why PSV-141B is needed: without it the full line pressure would reach RO-141A.

Table 7-1: Largest Release into B-101 and Resulting Concentration

Case	Pressure at RO-141A, psig	Release, scf/h	Concentration, vol %	Limit, vol %	Result
Normal supply, tubing break inside B-101	25	32	0.222	1.08	Meets
Regulator failed open, PSV-141B relieving	55	57	0.393	1.08	Meets

Case	Pressure at RO-141A, psig	Release, scf/h	Concentration, vol %	Limit, vol %	Result
Regulator failed open, no PSV-141B (not credible with PSV-141B)	1,150	1,096	7.091	1.08	Exceeds

Note 1: Concentration at the 250 cfm duty fan rate, well mixed. The dilution capacity of the fan at 25 % LFL is 157 scf/h.

B-101 is adequately ventilated and is classified Division 2 throughout, not Division 1. The credible releases are 32 and 57 scf/h, which MEA-CAL-004 and PRO-CAL-007 also report (32 and 57 scf/h) within rounding. Loss of ventilation is detected by FSL-208; EF-101B starts automatically, and if airflow is not restored within 5 minutes the safety PLC isolates all B-101 equipment that is not rated for Division 1 (XY-214D). Gas detectors GD-205 and GD-206 alarm at 20 % LEL and close SDV-141 at 40 % LEL, which provides a second layer independent of the ventilation.

8. UNCLASSIFIED AREAS AND IGNITION SOURCES

8.1. CONTROL AND ELECTRICAL BUILDING B-102

The Basis of Design requires B-102 to be outside all classified areas and at least 50 ft from any release source. Table 8-1 gives the distance from the B-102 walls to each group footprint and each Division 1 point source. The nearest is the Z-05 group, at 56.7 ft, so the requirement is met.

Table 8-1: Distance from B-102 to Release Sources

Release source	Extent	Distance, ft	Check (50 ft minimum)
Z-01 group	X 24 to 94, Y 25 to 42	109.0	Meets
Z-02 group	X 79 to 99, Y 52 to 59	106.1	Meets
Z-03 group	X 60 to 108, Y 89 to 116	111.3	Meets
Z-04 group	X 139 to 161, Y 84 to 96	67.6	Meets
Z-05 group	X 161 to 220, Y 88 to 96	56.7	Meets
Z-06 group	X 140 to 175, Y 138 to 148	111.1	Meets
Z-07 group	X 25 to 37, Y 80 to 105	173.1	Meets
Z-08 VS-101 outlet	(40, 160)	207.9	Meets
Z-10 VS-101 base	(40, 160)	207.9	Meets
Z-12 B-101 analyzer / GC / sampler vent header outlet above roof	(120, 121)	122.4	Meets
Z-14 PR-101 quick-opening closure	(24, 40)	179.2	Meets
Z-17 V-101 quick-opening closure, west end	(75, 40)	128.3	Meets
Z-20 T-101 interior	(30, 100)	186.3	Meets
Z-21 T-101 PVRV-193 / FA-193 NPS 6 breathing vent	(30, 100)	186.3	Meets
Z-29 T-101 EV-193 16 in emergency vent	(32, 100)	183.9	Meets
Z-24 T-101 truck loadout dry-break connection	(30, 116)	192.8	Meets

The B-102 outside-air intakes carry gas detector GD-207, which alarms at 20 % LEL and shuts down the building HVAC and closes its dampers. This guards against gas drawn in from an abnormal release, so B-102 does not need pressurization under NFPA 496.

8.2. CLEARANCE OF IGNITION SOURCES

Table 8-2 gives the plan clearance from each ignition source, or item of general-purpose equipment, to the nearest classified envelope, and confirms that each is unclassified at grade, at 3 ft and at 8 ft.

Table 8-2: Clearance of Ignition Sources to the Nearest Envelope

Item	Nearest envelope	Clearance, ft	Classification
B-102 control and electrical building	Z-05	47	Unclassified
G-101 standby generator enclosure	Z-04	52	Unclassified
G-101 fuel inlet, line 1052 riser	Z-04	52	Unclassified
XF-101 utility transformer	Z-05	69	Unclassified
H-101 burner and firebox openings	Z-06	21	Unclassified
CP-150 burner management panel	Z-05	24	Unclassified
ANT-201 antenna mast	Z-01	44	Unclassified
JB-W01 demarcation panel	Z-06	51	Unclassified

8.3. STANDBY GENERATOR G-101

G-101 is a natural gas engine generator in a weatherproof enclosure. It is an ignition source, through its engine, exhaust, alternator and controls, and it is not a process release source. Its fuel is supplied through the buried 1"-F-1052-A1 line from the fuel gas skid, regulated by PCV-162, and rises at the package fuel inlet, 21 ft from B-102. That separation has been accepted, because the fuel piping is welded carbon steel installed to NFPA 54 and the package fuel train (shutoff valves and zero-pressure regulator) is part of the listed engine installation under NFPA 37. Like any appliance fuel connection, it is not classified under RP 500. The enclosure is 52 ft and the fuel inlet 52 ft from the nearest envelope. G-101 is therefore unclassified and its electrical equipment is general purpose. The package vendor will confirm the NFPA 37 separation from B-102 and the combustion air and exhaust arrangement (HOLD H-15).

8.4. LIGHTING POLES

Table 8-3 shows the classification at the base and at the luminaire of each pole in ELE-CAL-007. No pole is in a Division 1 area. Five pole bases are within a Division 2 envelope, so their base handholes and junction boxes are Division 2 equipment. All area luminaires are specified Class I, Division 2, Group D, T4 regardless of location, so that one fixture type serves the whole station.

Table 8-3: Lighting Pole Classification

Pole	Location (X, Y), ft	Base	Envelopes at base	Luminaire at 25 ft
LP-P1	(40, 27)	Division 2	Z-01, Z-16	Unclassified
LP-P2	(100, 36)	Division 2	Z-01	Unclassified
LP-P3	(44, 114)	Division 2	Z-26	Unclassified

Pole	Location (X, Y), ft	Base	Envelopes at base	Luminaire at 25 ft
LP-P4	(137, 104)	Division 2	Z-04	Unclassified
LP-P5	(166, 110)	Unclassified	None	Unclassified
LP-P6	(226, 118)	Unclassified	None	Unclassified
LP-P7	(196, 42)	Unclassified	None	Unclassified
LP-P8	(150, 152)	Division 2	Z-06	Unclassified



9. EQUIPMENT AND WIRING REQUIREMENTS

9.1. ELECTRICAL EQUIPMENT

Table 9-1 lists the field electrical equipment in the load list ELE-CAL-001, its location, the area it is in and the minimum rating that results. Equipment inside B-102, such as the panelboards, transfer switch, UPS, chargers and batteries, is unclassified and general purpose.

Table 9-1: Field Electrical Equipment Ratings

Tag	Equipment	Location (X, Y), ft	Area	Minimum rating
SDV-101	Inlet SDV NPS 12, electro-hydraulic spring-return actuator, pump motor	(66, 28)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
SDV-102	OPSS SDV NPS 12, electro-hydraulic spring-return actuator, pump motor	(185, 88)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
SDV-103	Outlet SDV NPS 12, electro-hydraulic spring-return actuator, pump motor	(212, 88)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
MOV-111	Meter run valve MOV-111 NPS 10 Cl 600, electric quarter-turn actuator 480 V	(84, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
MOV-112	Meter run valve MOV-112 NPS 10 Cl 600, electric quarter-turn actuator 480 V	(84, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
MOV-121	Meter run valve MOV-121 NPS 10 Cl 600, electric quarter-turn actuator 480 V	(84, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
MOV-122	Meter run valve MOV-122 NPS 10 Cl 600, electric quarter-turn actuator 480 V	(84, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
MOV-115	Meter run valve MOV-115 NPS 10 Cl 600, electric quarter-turn actuator 480 V	(84, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
FCV-131	Flow control valve FCV-131, electric modulating actuator 480 V (duty)	(150, 84)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
FCV-132	Flow control valve FCV-132, electric modulating actuator 480 V (standby)	(150, 84)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
UH-101	B-101 electric unit heater 7.5 kW, Class I Div 2, thermostat	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum

Tag	Equipment	Location (X, Y), ft	Area	Minimum rating
E-161	Fuel gas electric preheater on 2"-F-1050 upstream of PCV-161 (FG-101), explosion-proof Class I Div 2, 5 kW rated, outlet 105 F	(88, 57)	Division 2	Class I Div 1 or Div 2 Group D, sheath T3 or better, high-limit cutout
EF-101A	B-101 ventilation exhaust fan duty 250 cfm, Class I Div 2 motor	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
EF-101B	B-101 ventilation exhaust fan standby 250 cfm, Class I Div 2 motor	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
GO-101A	Main gate swing operator 0.5 hp 480 V 3-phase (one per leaf)	(246, 48)	Unclassified	General purpose, NEMA 4X outdoors
GO-101B	Main gate swing operator 0.5 hp 480 V 3-phase (one per leaf)	(246, 76)	Unclassified	General purpose, NEMA 4X outdoors
RCP-101	Portable equipment receptacle 480 V 3-phase 30 A, Class I Div 2 (interlocked)	(90, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
AC-101	B-101 wall-mount AC 1.5 ton, Class I Div 2 package, 208 V 1-phase	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
LTG-B101	B-101 interior lighting, 2 x 40 W LED Class I Div 2	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
REC-B101	B-101 duplex receptacles, Class I Div 2 factory sealed (2 x 180 VA)	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
REC-EXT-1	Exterior GFCI receptacles, Class I Div 2: SK-110 and FCV station (2 x 180 VA)	(90, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
REC-EXT-2	Exterior GFCI receptacle, Class I Div 2: inlet area (1 x 180 VA)	(60, 30)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
REC-EXT-3	Exterior GFCI receptacle, H-101 burner end (1 x 180 VA)	(214, 132)	Unclassified	General purpose, NEMA 4X outdoors
AE-141H	GC oven / analytical heater (generator-backed, not on UPS)	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
SCS-141	GC sample conditioning enclosure heater 200 W	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum

Tag	Equipment	Location (X, Y), ft	Area	Minimum rating
HT-1080	Heat tracing circuit HT-1080: 3/8 in analyzer transport 1080, 16 ft x 15 W/ft self-regulating, plus SP-141 heated regulator 100 W, controller + GFEP	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
HT-1139	Heat tracing circuit HT-1139: 1/4 in composite sampler line 1139, 16 ft x 15 W/ft self-regulating, controller + GFEP	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
AHT-142/143	AT-142 and AT-143 analyzer enclosure heaters 2 x 100 W	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
CP-150	BMS-150 panel (SIL 2 BMS): controller, igniter BY-153, XV-150A/B/C, TCV-152 actuator, flame rod BE-153A and UV scanner BE-153B	(214, 132)	Unclassified	General purpose, NEMA 4X outdoors
SDV-165	Fuel gas SDV NPS 1, electro-hydraulic actuator pump 0.25 hp 120 V	(97, 51)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
G-101BH	G-101 engine block heater 1,500 W 120 V	(190, 24)	Unclassified	General purpose, NEMA 4X outdoors
G-101BC	G-101 starting battery charger 12 VDC 6 A, 120 V	(190, 24)	Unclassified	General purpose, NEMA 4X outdoors
JB-W01	 demarcation panel 120 VAC supply (HOLD H-14)	(214, 197)	Unclassified	General purpose, NEMA 4X outdoors
LCV-104	V-101 dump valve electric actuator (running 60 W, standby 10 W)	(81, 35)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
SDV-106	V-101 liquid outlet SDV, electric spring-return fail-closed actuator (holding 20 W, stroke 100 W)	(87, 36)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
ANT-201	Mast base enclosure: surge-protected 120 VAC outlet for mast-mounted telecom equipment (typical, HOLD H-15)	(150, 22)	Unclassified	General purpose, NEMA 4X outdoors
JB-140D	B-101 analyzer DC distribution: AT-141, AT-142, AT-143, AT-144, SMP-146	(111, 115)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
JB-110D	SK-110 ultrasonic meter electronics FT-111, FT-121	(90, 87)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum
FT-163	FG-101 Coriolis transmitter FT-163	(97, 51)	Division 2	Class I Div 2 Group D (or explosion-proof), T3 minimum

Note 1: Location is the equipment or its field termination point in plant coordinates. Heaters and heat tracing in classified areas carry a marked temperature class (NEC 501.130; IEEE 515 for heat tracing).

9.2. WIRING METHODS AND SEALS

Table 9-2 sets the wiring methods and seals that follow from the classification. The most important practical point is sealing: every conduit that leaves a classified envelope, enters B-101 or enters B-102 from the process area is sealed, so that gas cannot travel through the raceway into an unclassified space.

Table 9-2: Wiring Method and Seal Requirements

Area or item	Requirement
Division 1	No electrical equipment is located in Division 1 except the T-101 level transmitter LT-191, which is intrinsically safe or flameproof. Wiring is threaded rigid metal conduit (PVC-coated) or Type MC-HL or TC-ER-HL cable with listed fittings (NEC 501.10(A)). Seals within 18 in of every explosion-proof enclosure containing arcing devices and at every Division 1 boundary (NEC 501.15(A)).
Division 2	Threaded PVC-coated rigid metal conduit above grade, or Type TC-ER-HL, MC-HL or ITC-HL cable with listed glands (NEC 501.10(B)). Flexible connections use listed liquidtight flexible conduit with a bonding jumper. Enclosures with make-and-break contacts that are not hermetically sealed or nonincendive are sealed (NEC 501.15(B)(1)).
Division 2 boundary	Conduit leaving a Division 2 envelope is sealed within 10 ft of the boundary, with no union, coupling or fitting between the seal and the boundary (NEC 501.15(B)(2)). Underground conduit that rises within an envelope is sealed at the riser above grade.
B-101 wall	Every conduit entering B-101 is sealed at the wall, and the SDV-141 and sample tubing penetrations are sealed gas-tight.
B-102 entry	Every conduit arriving from the process area is sealed at the B-102 floor or wall entry. Spare conduits are capped and sealed. Cable tray is not used between areas.
Below grade	Below-grade raceway within an envelope is unclassified for lighter-than-air gas provided there are no pits. No cable pits or open trenches are permitted within envelopes; handholes in envelopes are sand-filled or sealed.
Temperature class	T3 (200 °C) minimum in Division 1 and Division 2, below the 225 °C lowest AIT; T4 preferred. Heat tracing and E-161 sheath temperature limited by design or controller to the marked class.
Bonding	Locknut-bushing and double-locknut connections are not relied on for bonding; bonding bushings or jumpers are used at all classified-area enclosures (NEC 501.30, 250.100).
Portable equipment	Receptacle RCP-101 and the exterior receptacles are Class I, Division 2 rated and interlocked, and are used only under a hot-work and gas-test permit.

10. SUMMARY AND CONCLUSIONS

TORUS draws the following conclusions:

1. The station gas is lighter than air (relative density 0.638), NEC Group D, with an LFL of 4.65 vol % for the design case and a lowest component autoignition temperature of 225 °C. Equipment in every classified area shall be rated T3 or better.
2. Division 1 is limited to the vent and relief outlets, the PR-101 and V-101 closures, the T-101 interior and vents, and the truck loadout connection. The rest of the process area is Division 2, within 10 ft of each equipment group.
3. B-101 is adequately ventilated (2.08 cfm/ft², 13.9 air changes per hour). The largest credible release, 57 scf/h through RO-141A with PSV-141B relieving, gives 0.39 vol % against a limit of 1.08 vol %. The shelter is Division 2.
4. B-102 is 57 ft from the nearest release source and outside every envelope. G-101, XF-101 and the H-101 burner are also outside every envelope; the H-101 burner is 21 ft from the nearest one.
5. The H-101 burner end remains unclassified only if the fuel train meets the three conditions in Section 6.5. The heater specification shall carry them.

The next step is to confirm the equipment heights, the T-101 containment wall height and the analyzer vent routing against vendor drawings, and to update ELE-DWG-002 and this report before the design is issued for construction. The following items remain open: vendor data for the heater fuel train, E-161 surface temperature, the generator package and the analyzer shelter (HOLD H-15); and the receiving pipeline operator's point list for the demarcation panel (HOLD H-14), which does not affect the classification.