FIREWATER SYSTEM FOR OFFSHORE FACILITIES

presented by:
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OUTLINE

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I.N.T.R.O.D.U.C.T.I.O.N

FIREWATER SYSTEM

- FW systems are one of the systems which used to reduce the risk of fire and explosion – Active Fire Protection (AFP).
- Intended to mitigate the consequences of fire/explosion event by extinguishing or limiting the spread of fire.

O.B.J.E.C.T.I.V.E.S

OBJECTIVES

- To find maximum firewater demand required for a single major fire scenario which will dictate the firewater pump capacity
- To determine required FW pump discharge pressure (to meet the most hydraulically remote fire fighting equipment)
- To preliminarily size the FW ringmain and other pipeworks

D.E.S.I.G.N B.A.S.I.S & P.H.I.L.O.S.O.P.H.Y

DESIGN OBJECTIVE

- The purposes of providing FW systems on offshore facilities including followings:
  - To protect personnel
  - Minimise fire damage and thus enable the facility return to operation ASAP after fire
  - Minimise escalation which could lead to major damage and environmental pollution.

DESIGN OBJECTIVE cont'd

- Water can reduce the potential risk resulting from fire by:
  - Cool high flashpoint liquids or combustible solid material
  - Suffocates the fire when water is converted to steam
  - Blankets pool fires when applied with foam
  - Cool the environment (air, hot gas, flame, smoke etc) to limit the spread of fire by convection
  - Cool adjacent facilities or structures to prevent fire spread by radiation effects
  - Forming heat absorbing barrier between fire and facilities

DESIGN PHILOSOPHY

- In general, the whole facilities will be treated as single fire area. However, if the FW demand for such area cannot be satisfied, additional physical separation can be employed
- Zoning segregation is deemed effective enough that only single fire scenario is assumed to occur at any given time
- Design FW demand is dictated be the largest FW demand of a single fire event
  - Requirement for personnel protection during escape and evacuation / manual fire-fighting by personnel
  - The FW demand which will be initiated upon fire detection

DESIGN PHILOSOPHY cont'd

- Operating pressures of fire-fighting equipments such as monitors, hosereels n light water station are rated at 7.0 barg (100 psig)
- FW pump shall be sized to provide either 100% of the calculated design fire water demand or an appropriate fraction of adopted sparing philosophy
- FW ringmain and other piping within the Wet system will constantly pressurized by jockey pump(s)

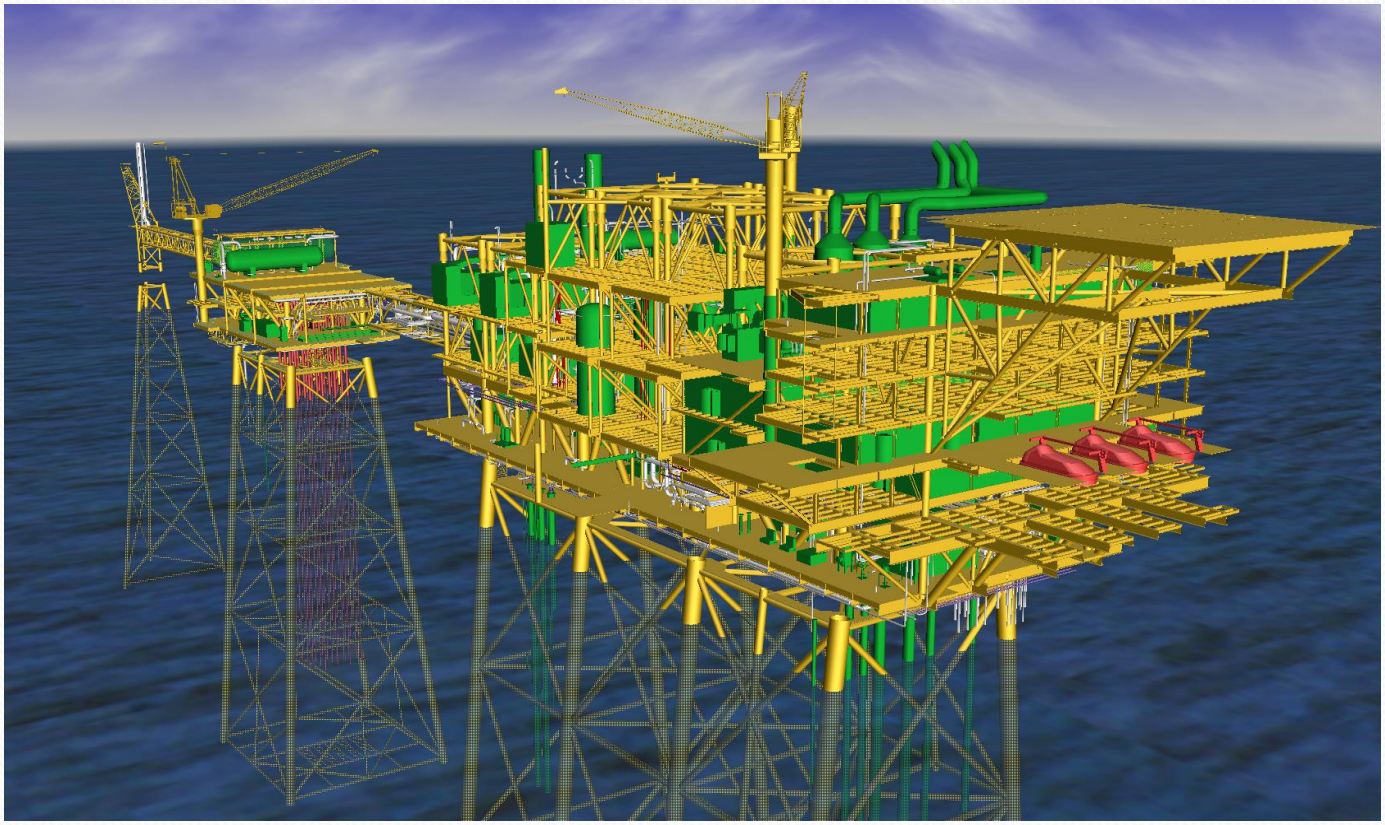
DESIGN PHILOSOPHY cont'd

- As per NFPA 20 requirements, the FW pump shall have maximum capacity not less than 150% of rated capacity with differential head not less than 65% of differential head at rated capacity.

3-2* Factory and Field Performance. Pumps shall furnish not less than 150 percent of rated capacity at not less than 65 percent of total rated head. The shutoff head shall not exceed 140 percent of rated head for any type pump. *(See Figure A-3-2.)*

CASE STUDY

- FW system on TBCP-A facilities is taken as case study.



F.I.R.E A.R.E.A Z.O.N.I.N.G

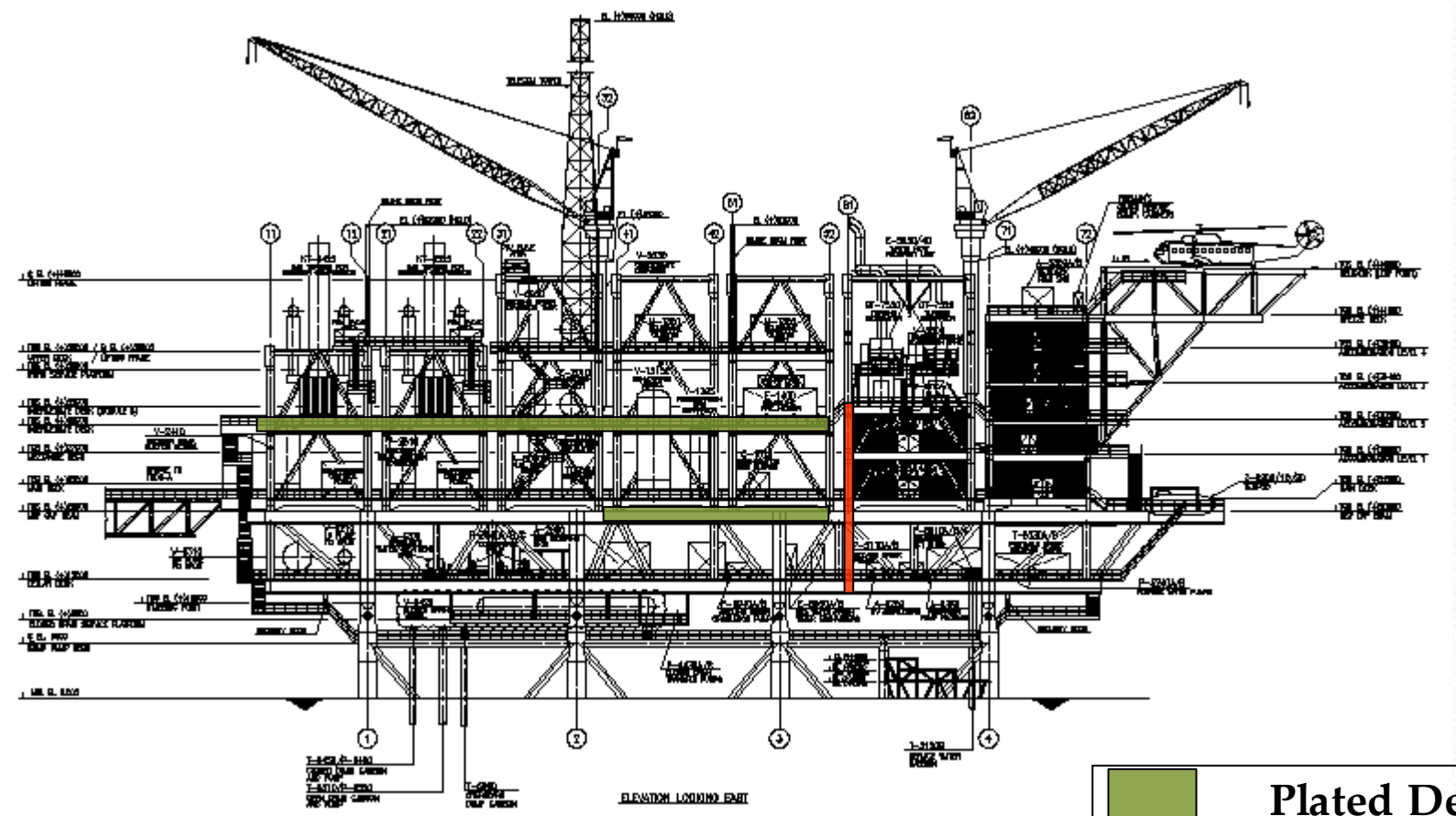
FIRE AREA ZONING

- In order to minimize design (largest) FW demand, the facilities (one large fire area) will be divided into several smaller fire area as reasonably practicable
- This can be achieved either by employing physical separation or by forming heat absorbing barrier between fire and facilities upon fire event
- Physical separation is achieved by installing/providing firewall, plated deck etc
- Heat absorbing barrier is formed when the adjacent/ neighbouring fire area is spray with water

FIRE AREA ZONING cont'd

- Each fire area is provided with automatic deluge valve (ADV) or alternatively actuated isolation valve with RO at the inlet from FW ringmain
- Upon detection of fire, the affected ADV(s) will be activated (open) to discharge FW to the affected equipments/area.
- In addition, the adjacent/neighbouring fire zone which exposed to radiation will be deluged as well.

FIRE AREA ZONING cont'd



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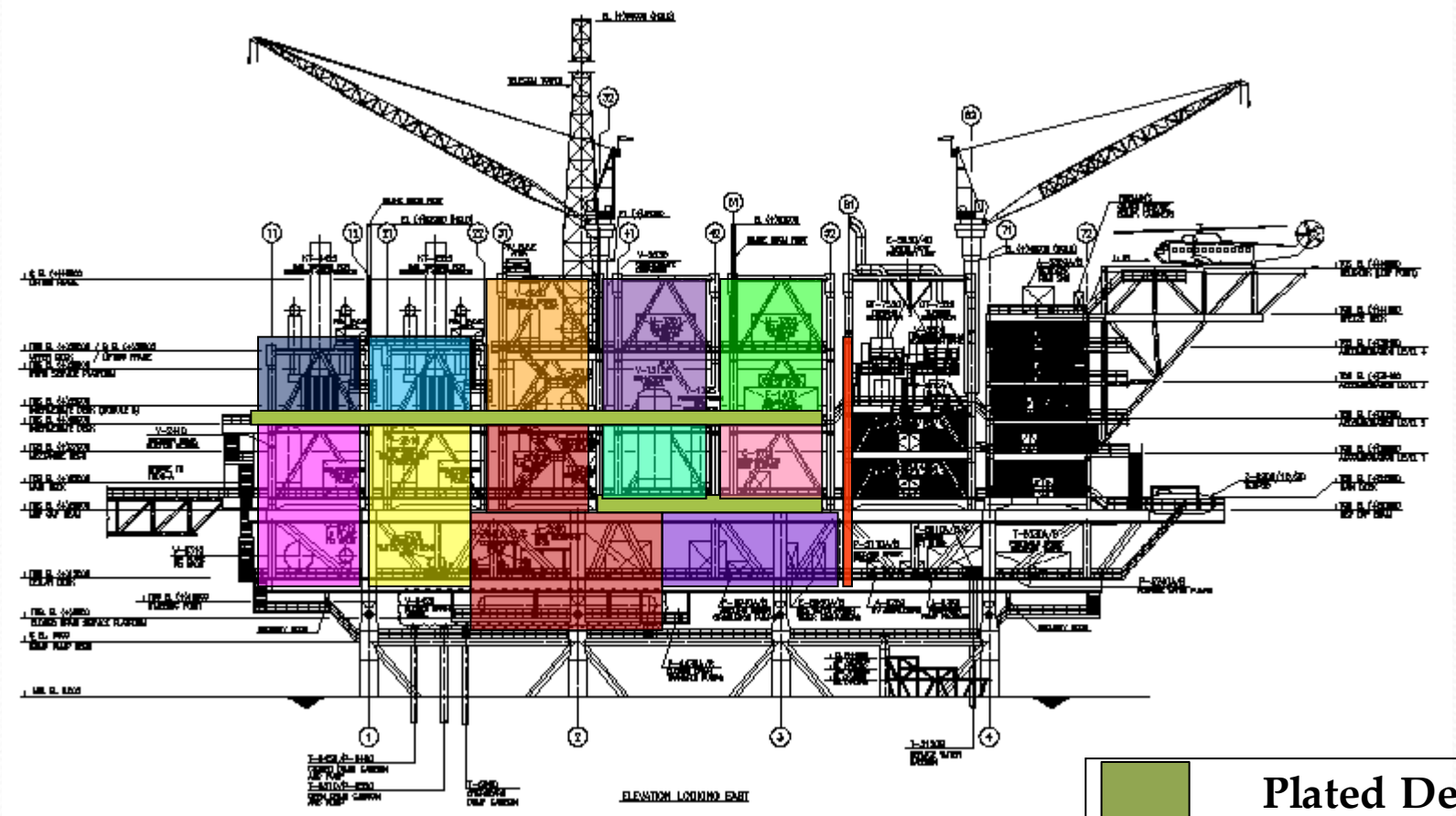


FIRE AREA ZONING cont'd

- From the equipment layout, it is possible to segregate the facilities into 11 independent fire zones which require 11 nos of ADV.

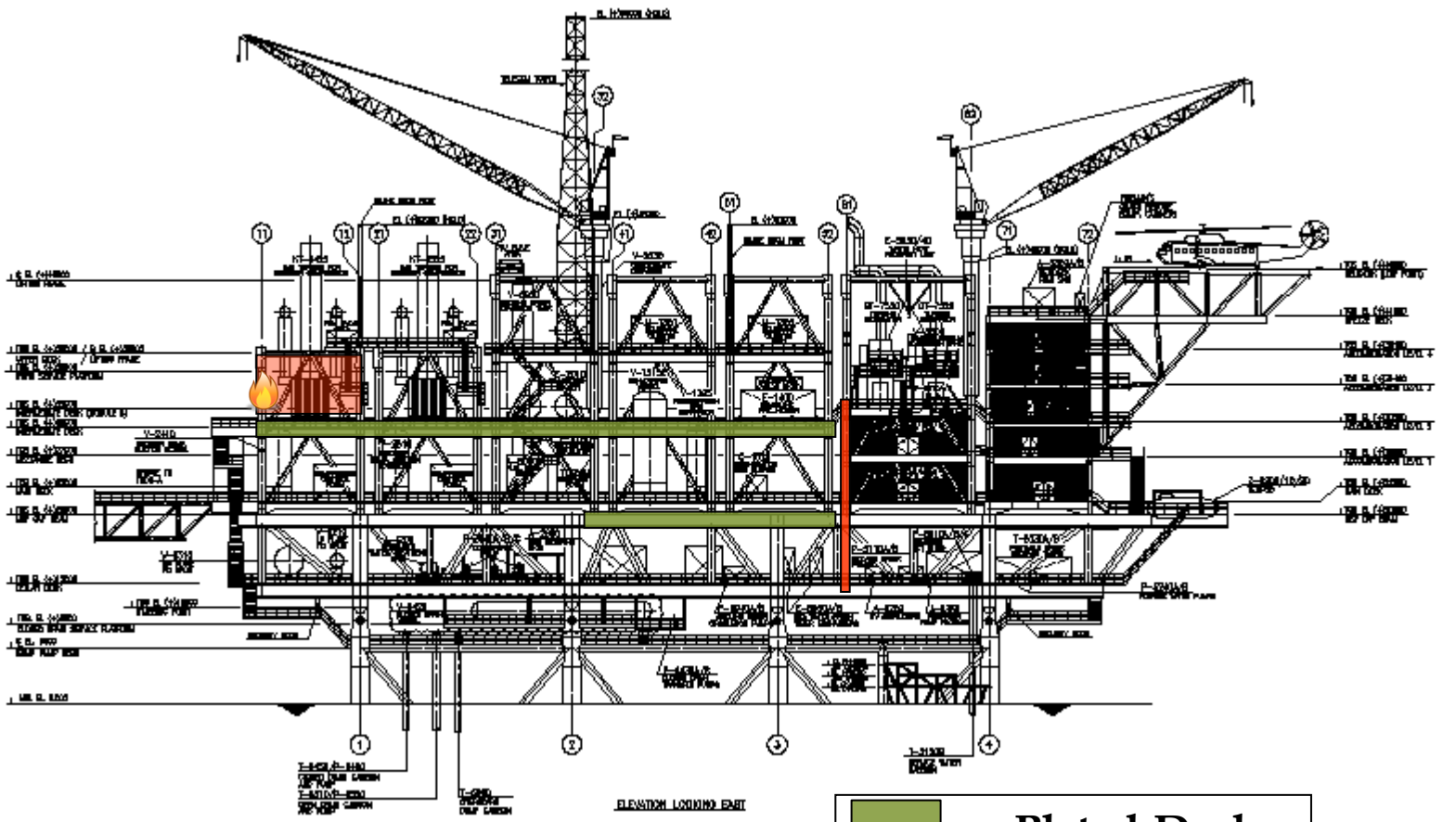
P.O.S.S.I.B.L.E. M.A.J.O.R. F.I.R.E. S.C.E.N.A.R.I.O.S.

POSSIBLE MAJOR FIRE SCENARIOS

- List of possible major fire scenarios:

No.	Scenarios		No.	Firewater Demand
1	Fire in module 1 Level 2 (North Side)		14	Fire in module 4 Level 3 or Level 2 (South Side)
2	Fire in module 1 Level 2 (South Side)		15	Fire in module 4 Level 1 (North Side)
3	Fire in module 1 Level 1 or Cellar Deck (North Side)		16	Fire in module 4 Level 1 (South Side)
4	Fire in module 1 Level 1 or Cellar Deck (South Side)		17	Fire in module 4 Cellar Deck (North Side)
5	Fire in module 2 Level 2 (North Side)		18	Fire in module 4 Cellar Deck (South Side)
6	Fire in module 2 Level 2 (South Side)		19	Fire in module 5 Level 3 or Level 2 (North Side)
7	Fire in module 2 Level 1 or Cellar Deck (North Side)		20	Fire in module 5 Level 3 or Level 2 (South Side)
8	Fire in module 2 Level 1 or Cellar Deck (South Side)		21	Fire in module 5 Level 1 (North Side)
9	Fire in module 3 Level 3 or Level 2 (North Side)		22	Fire in module 5 Level 1 (South Side)
10	Fire in module 3 Level 3 or Level 2 (South Side)		23	Fire in module 5 Cellar Deck (North Side)
11	Fire in Module 3 Level 1 or Cellar Deck (North Side)		24	Fire in module 5 Cellar Deck (South Side)
12	Fire in Module 3 Level 1 or Cellar Deck (South Side)		25	Fire in Helideck Area
13	Fire in module 4 Level 3 or Level 2 (North Side)			

MAJOR FIRE SCENARIOS cont'd



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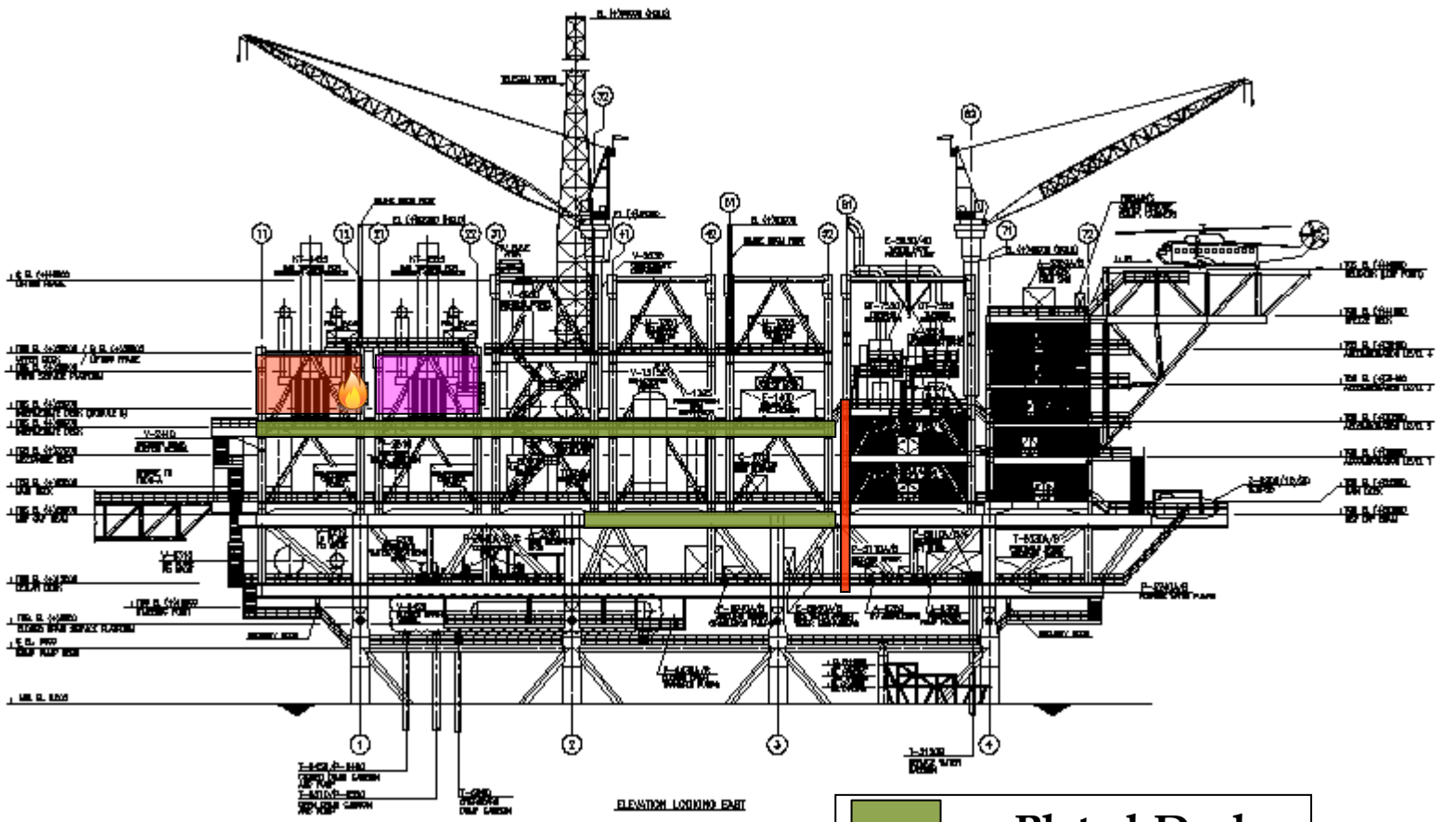

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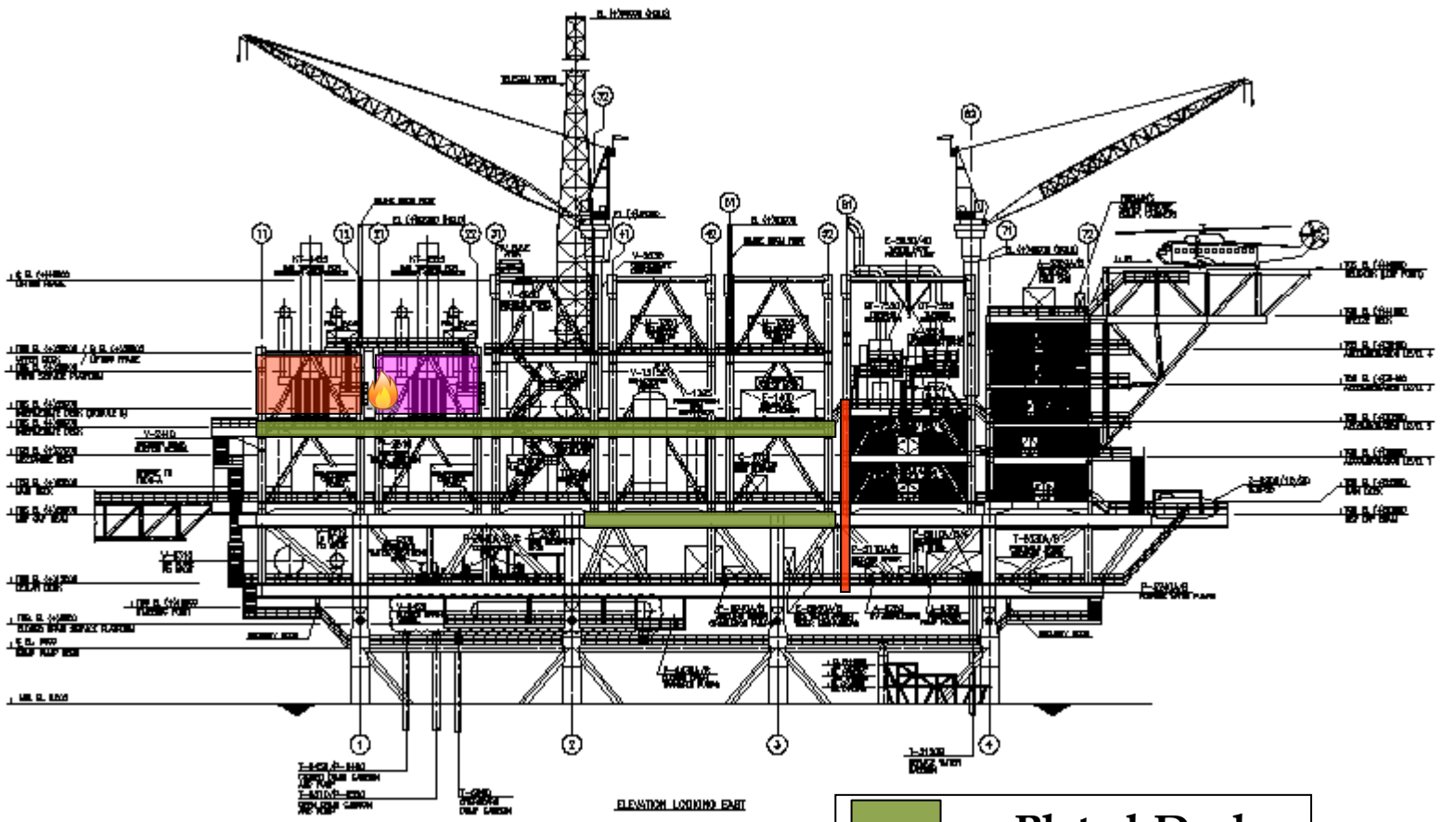

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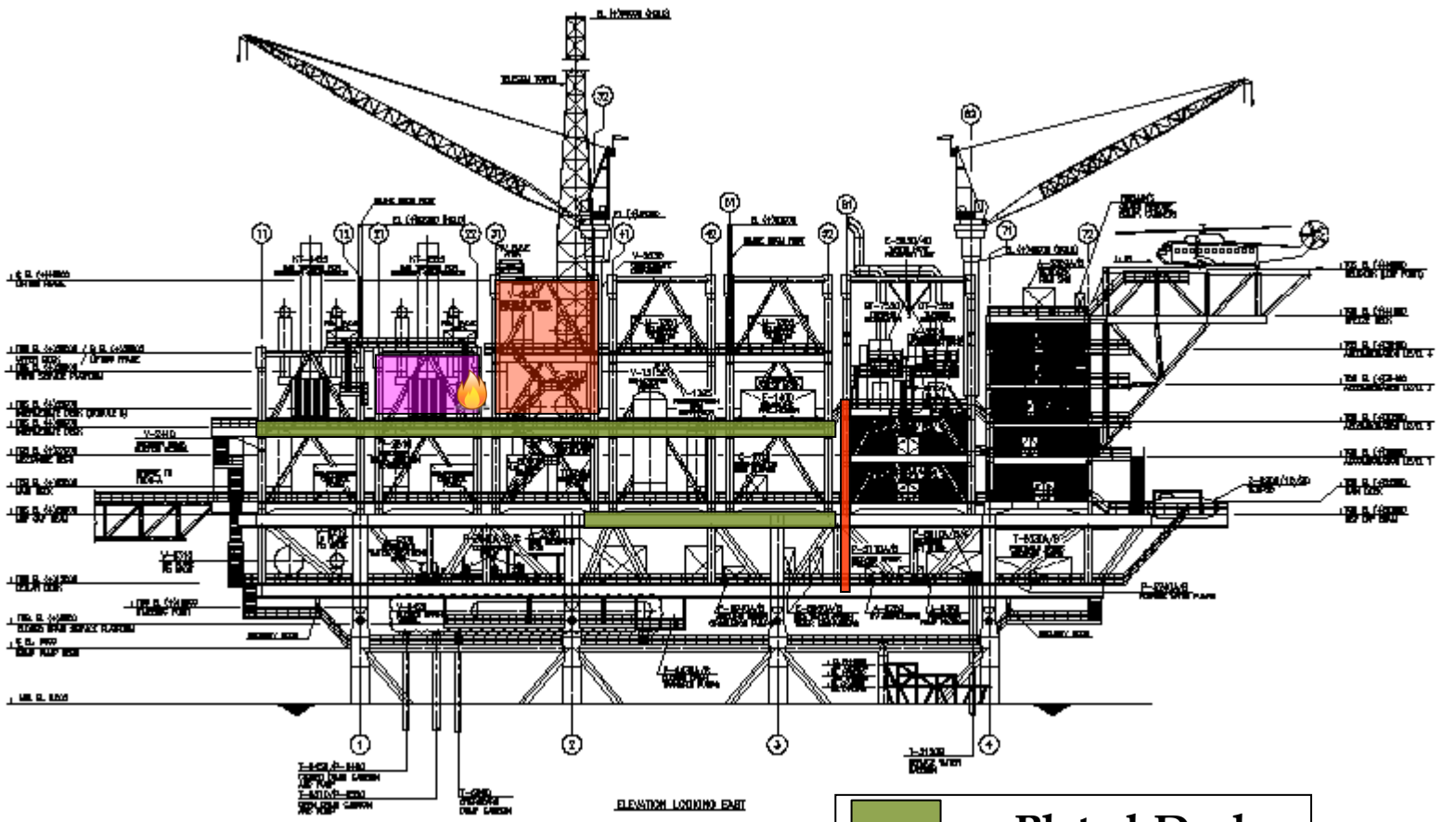

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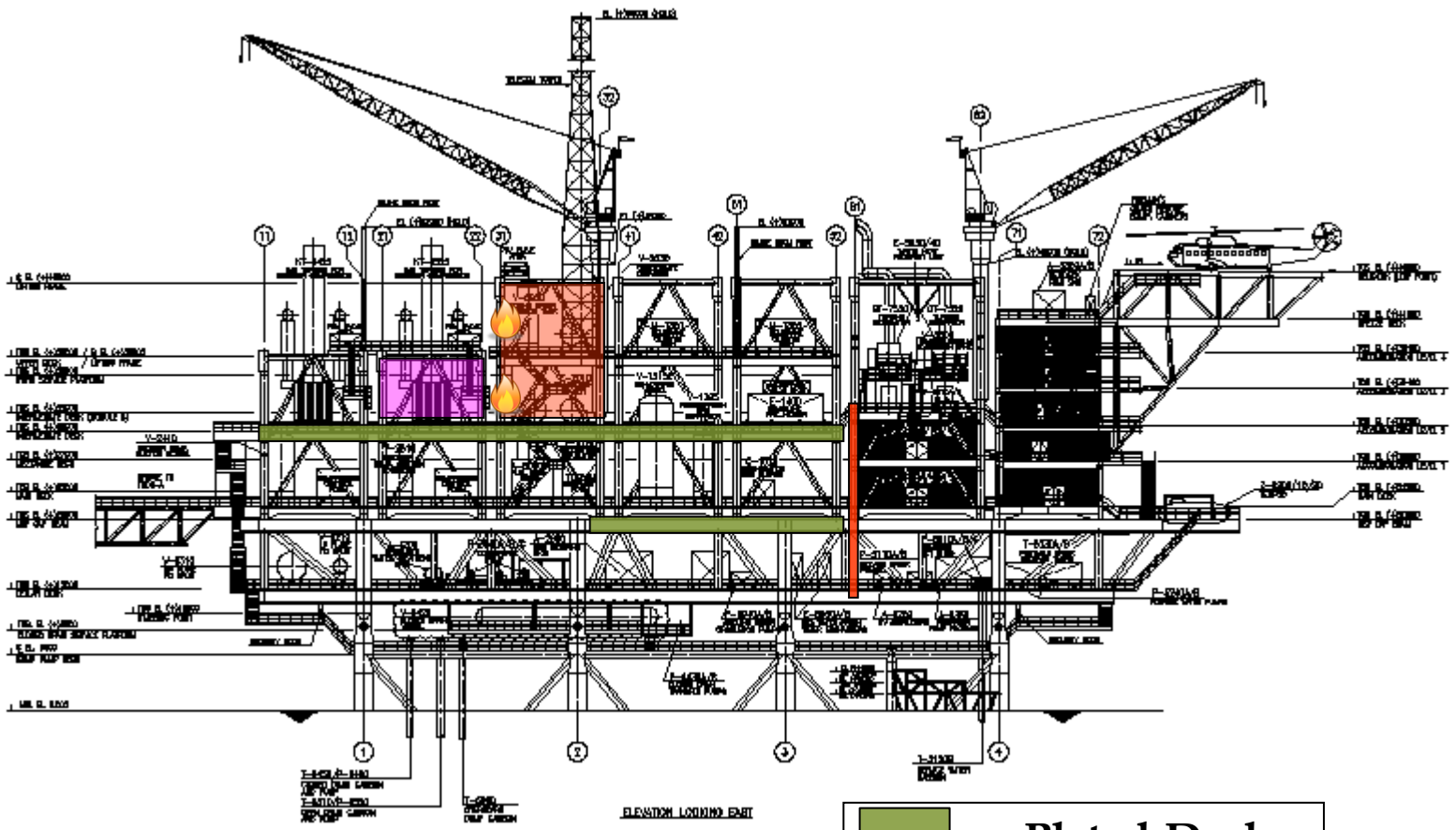

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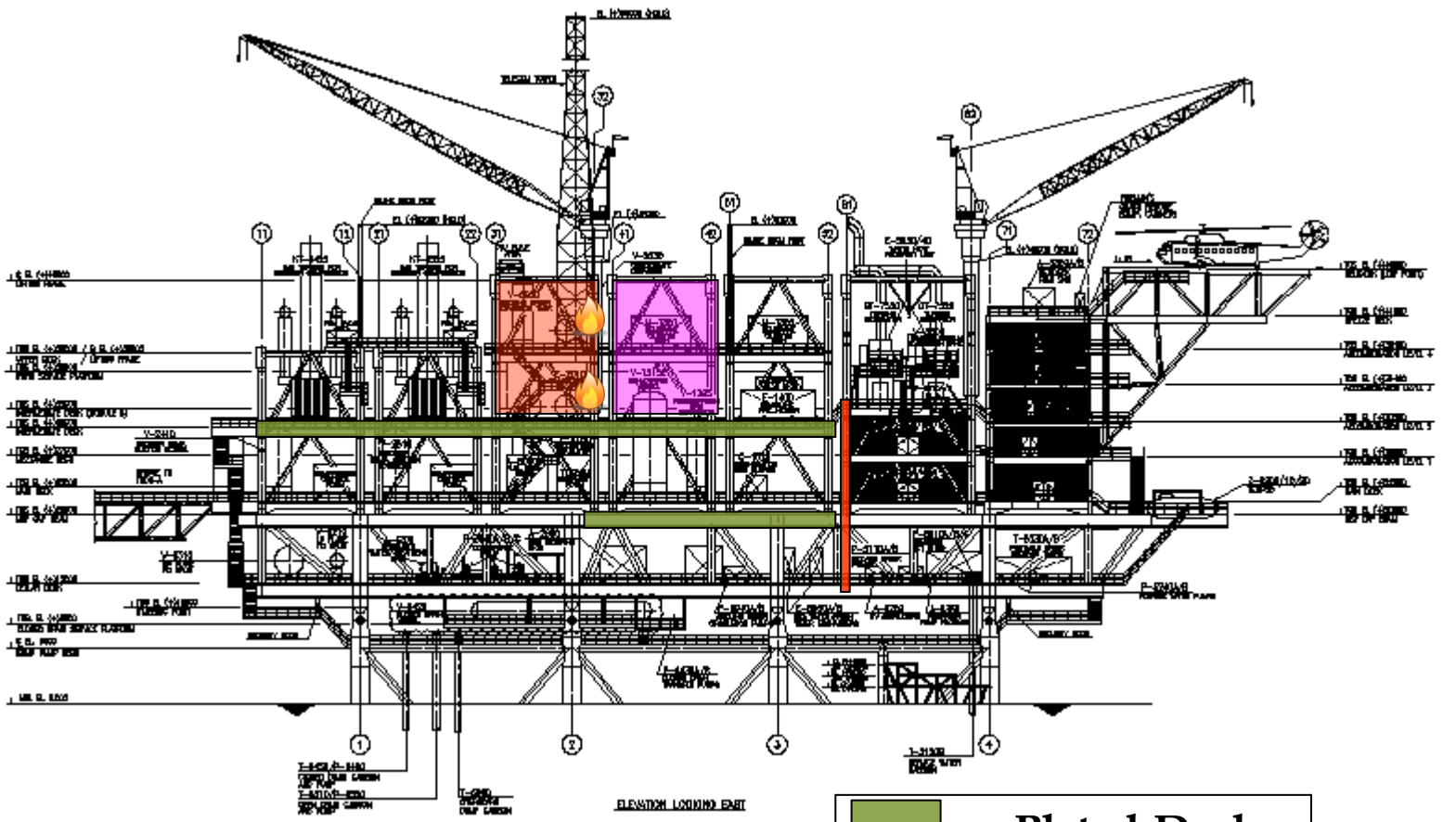

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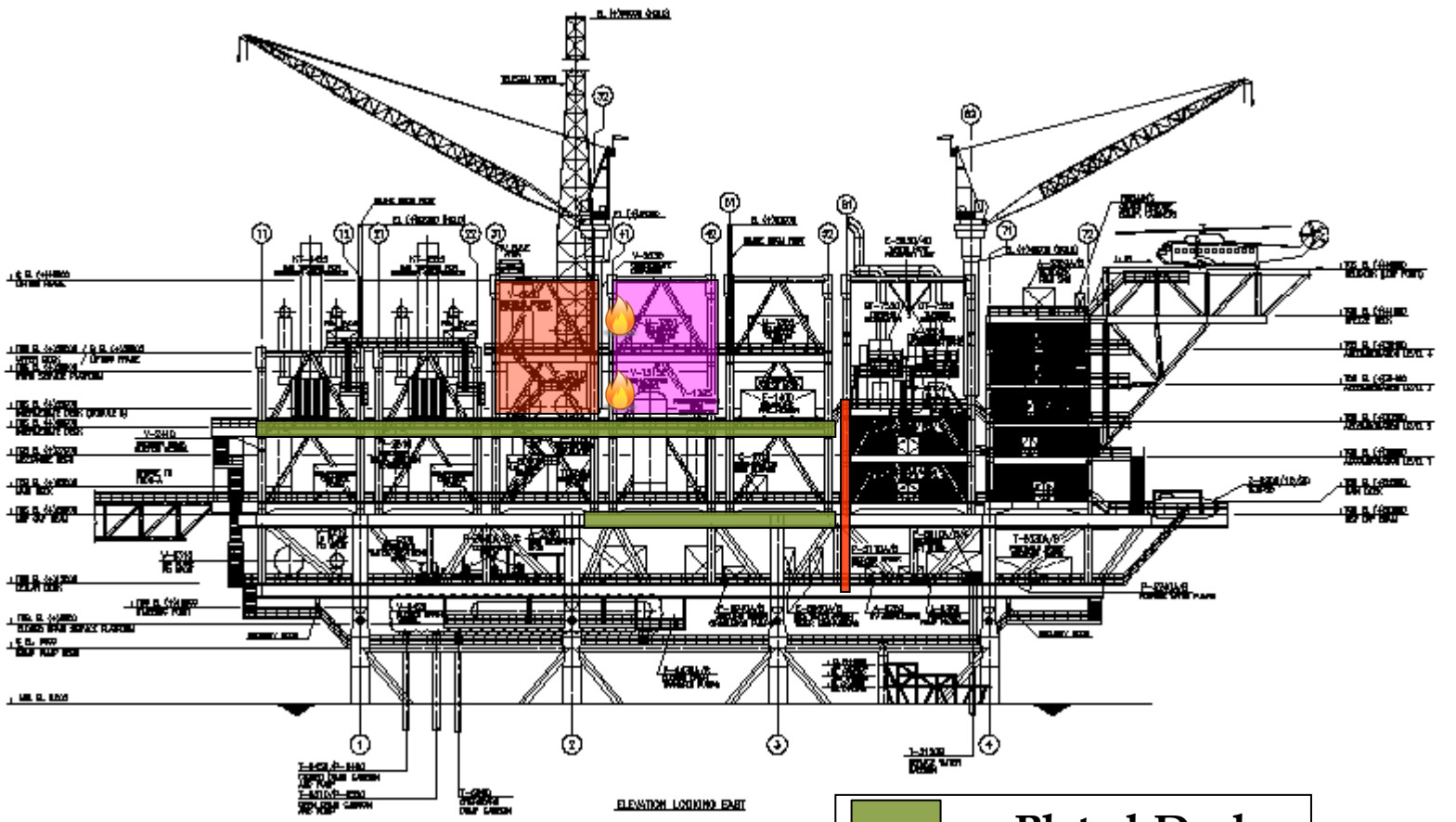

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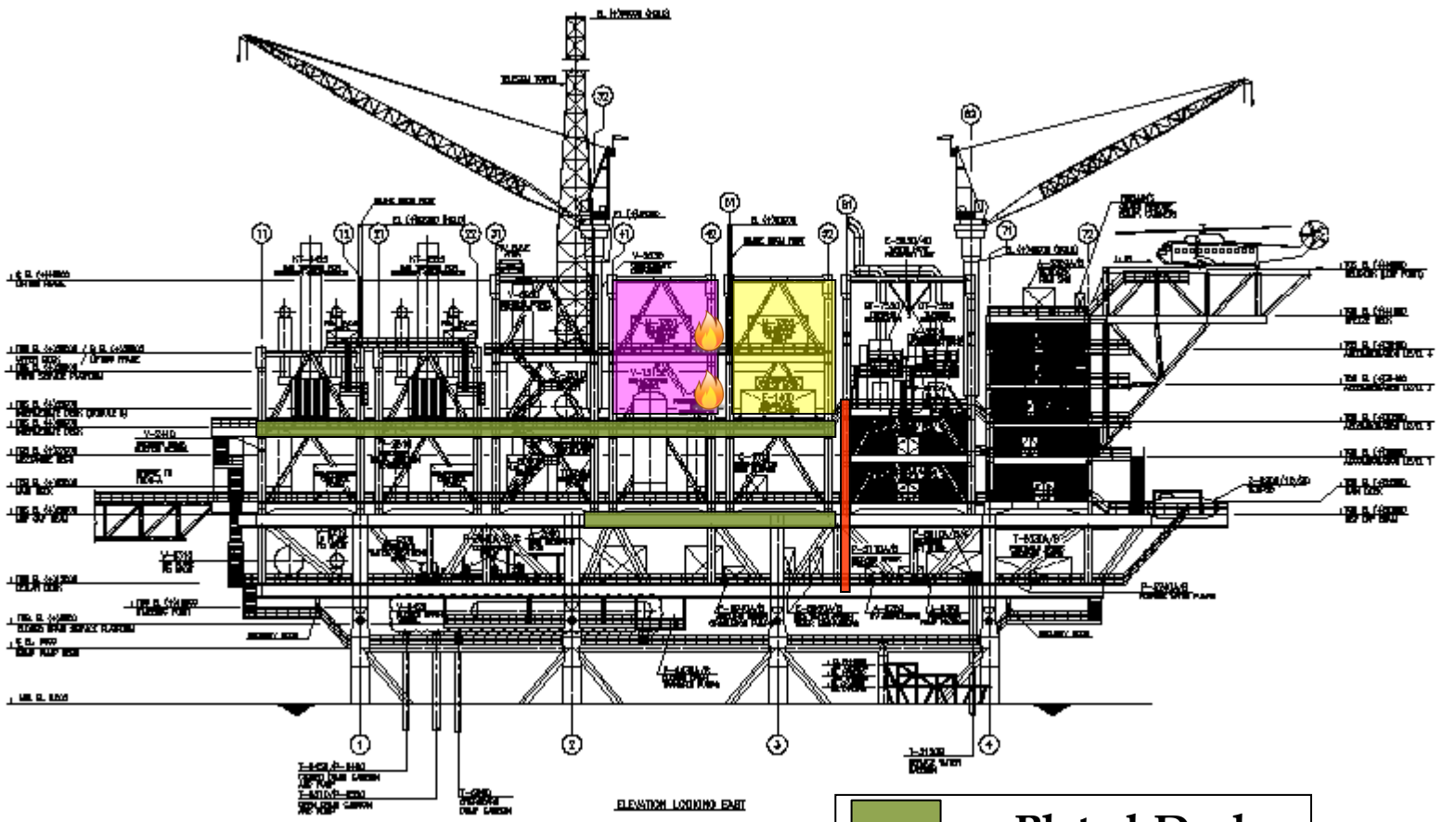

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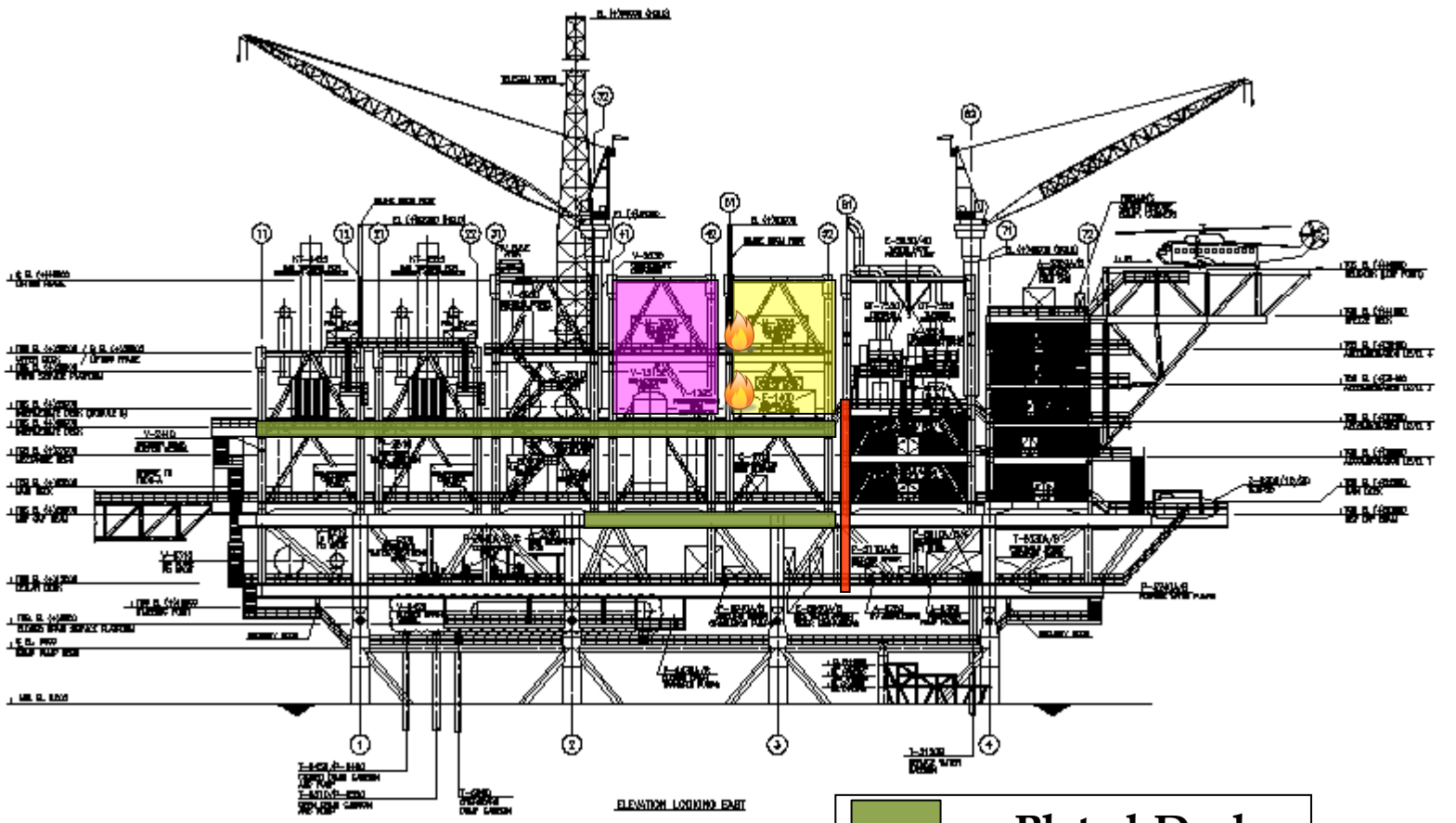

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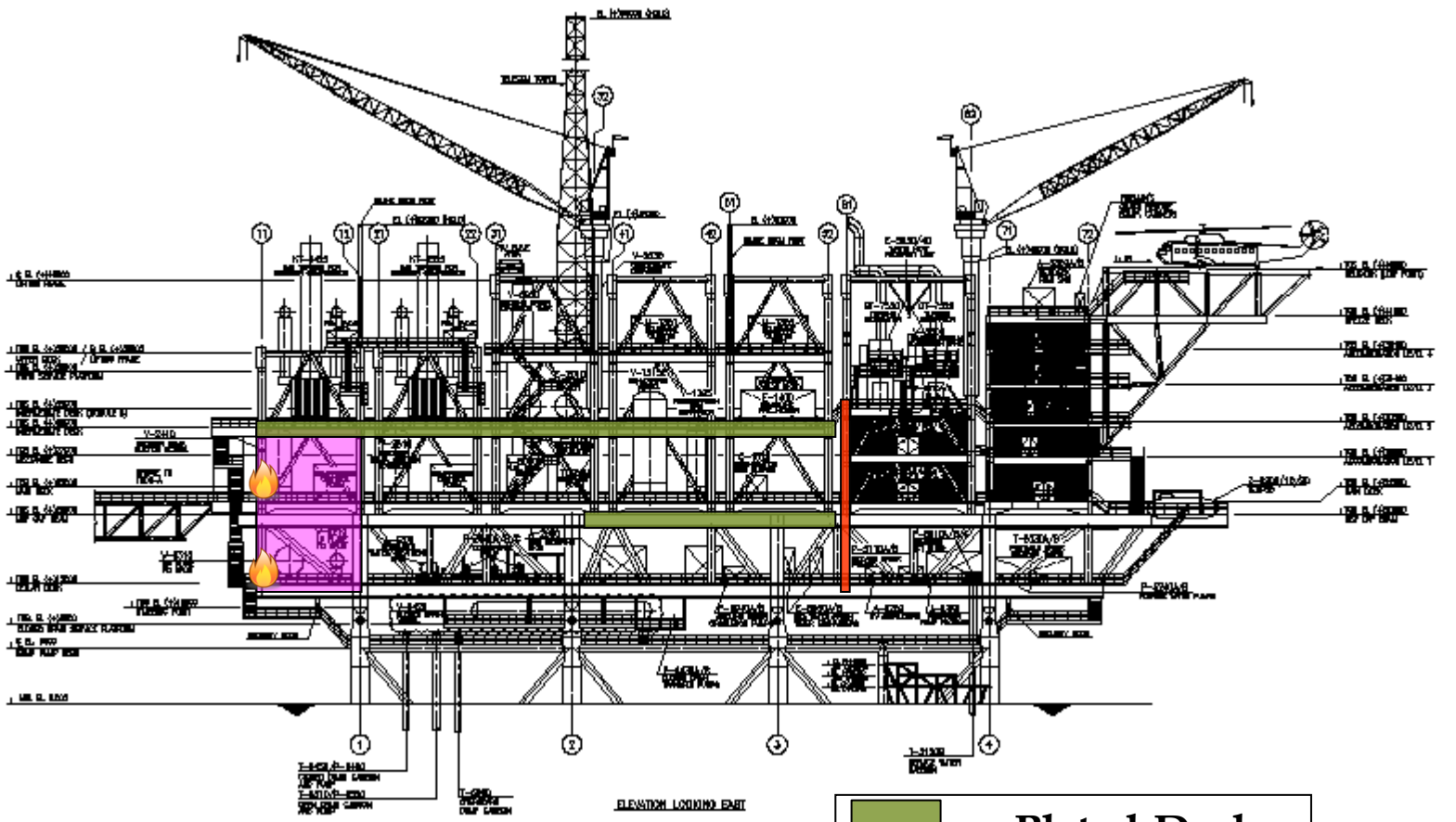

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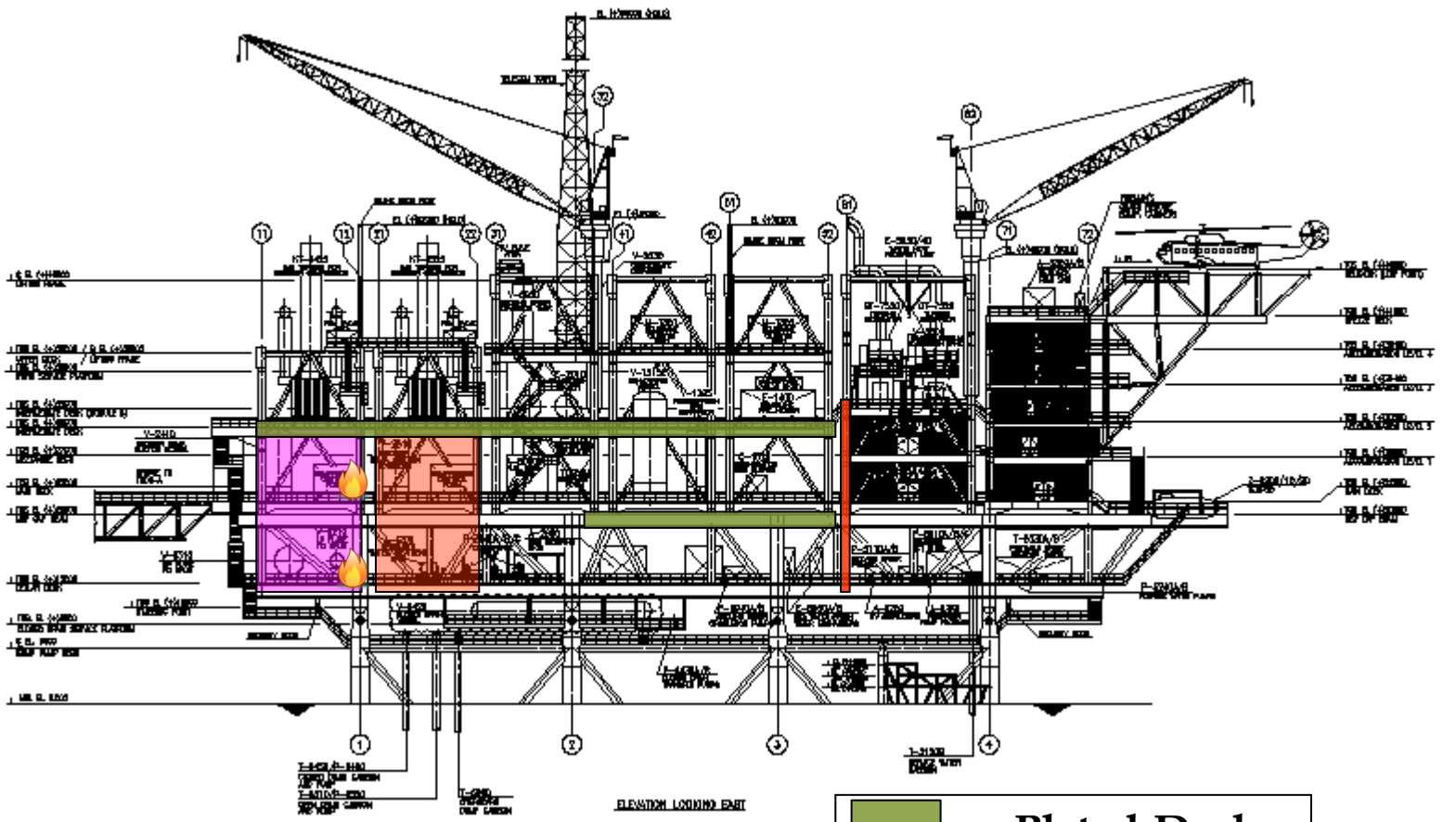

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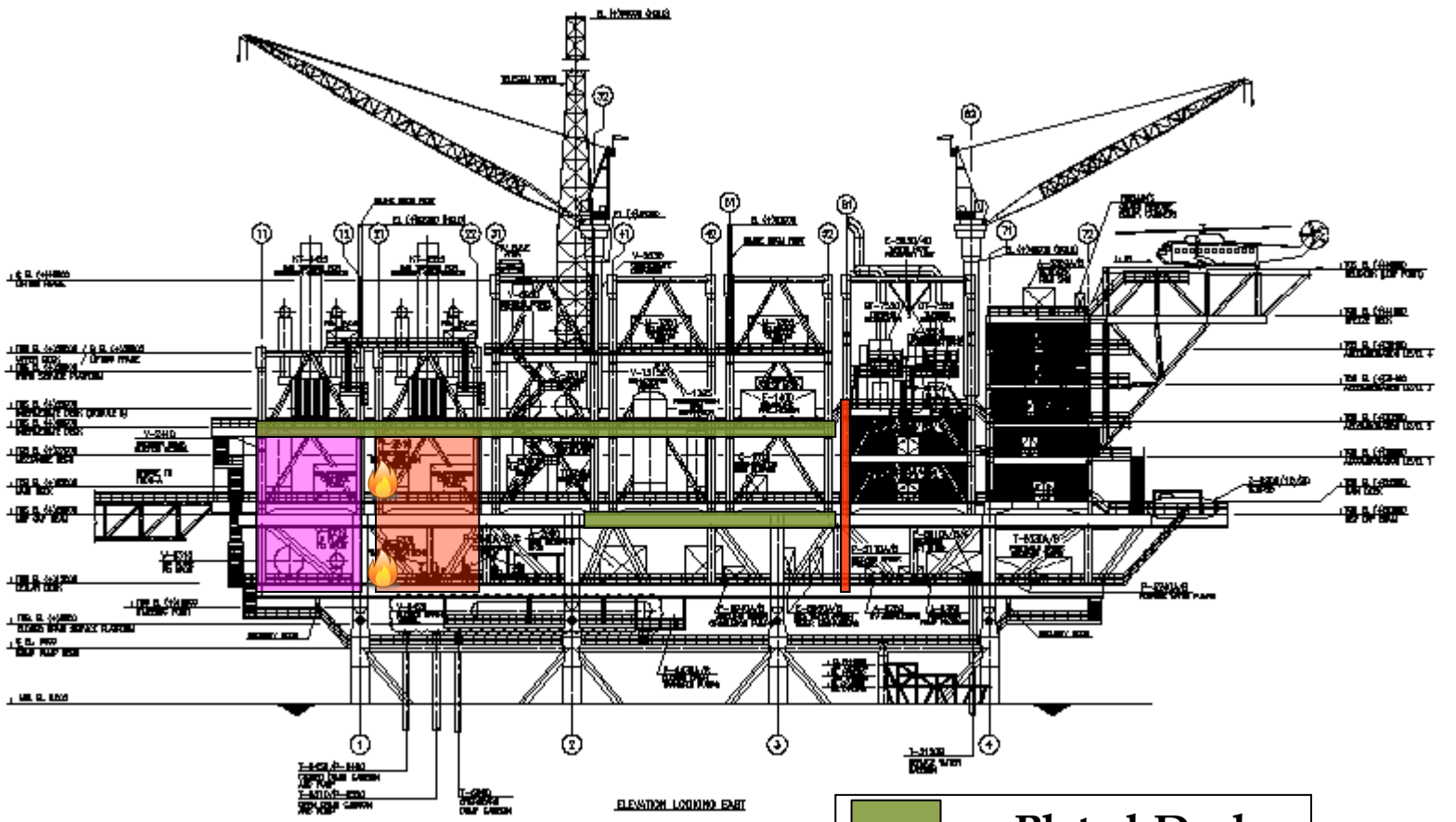

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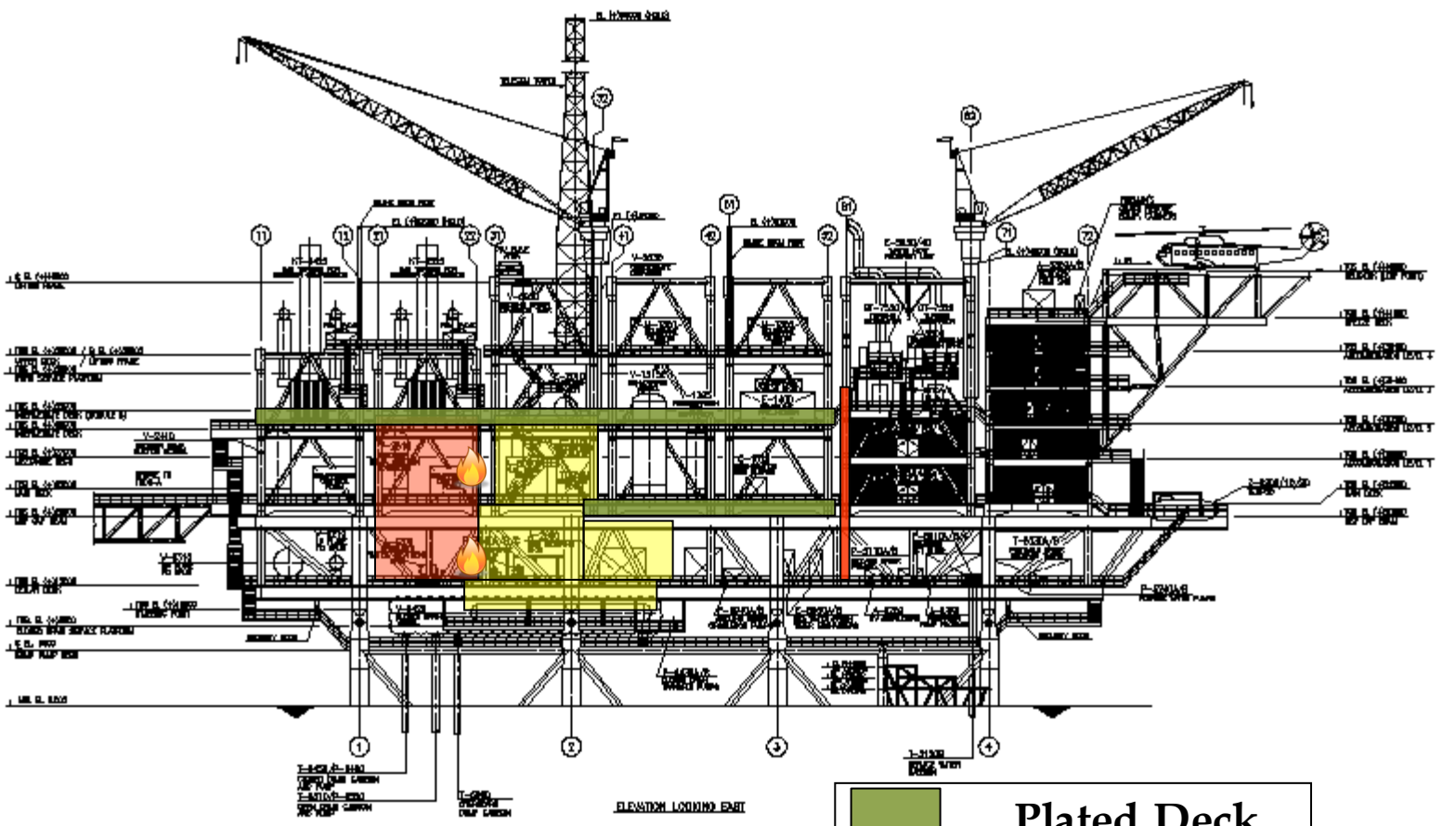

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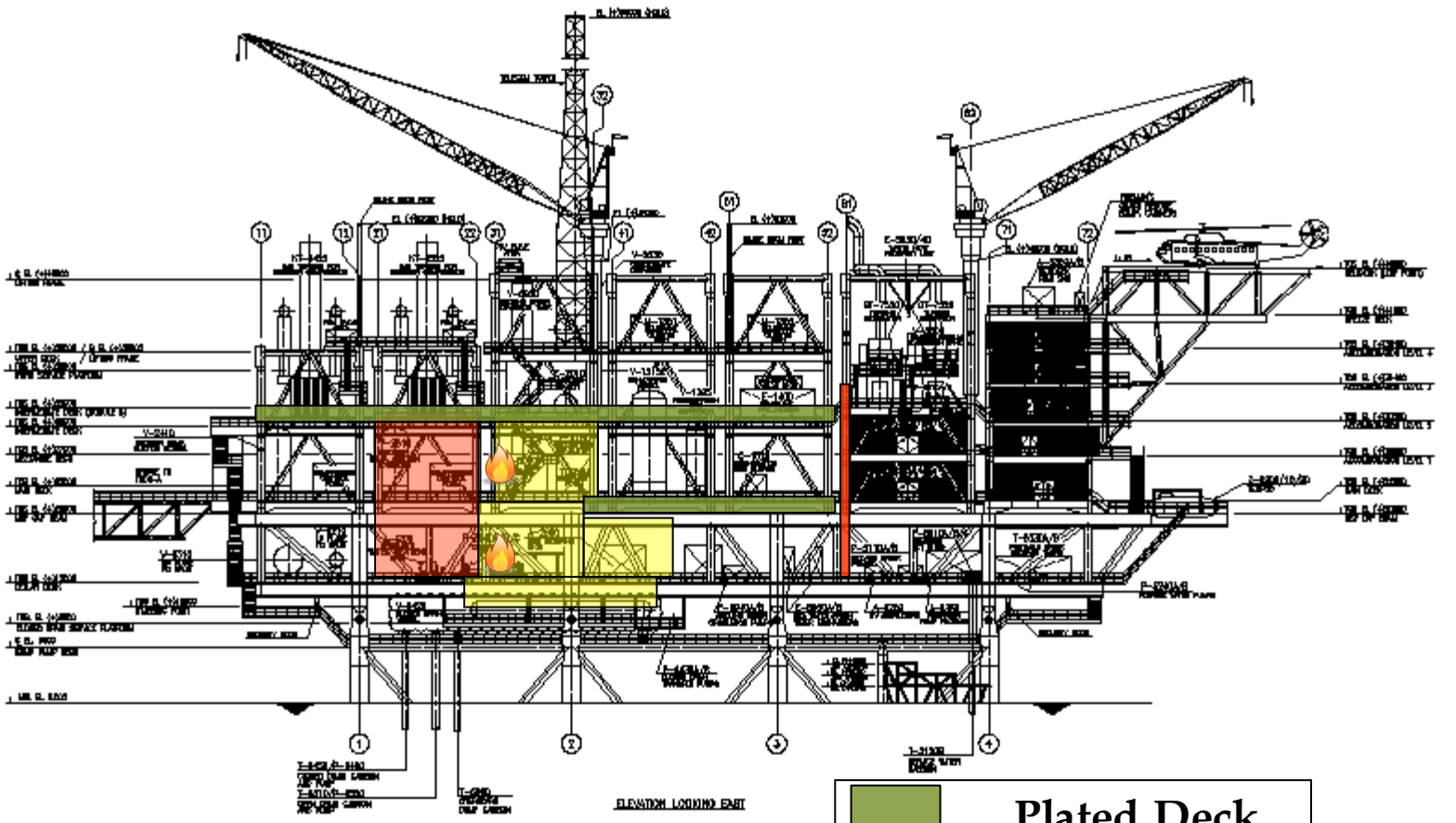

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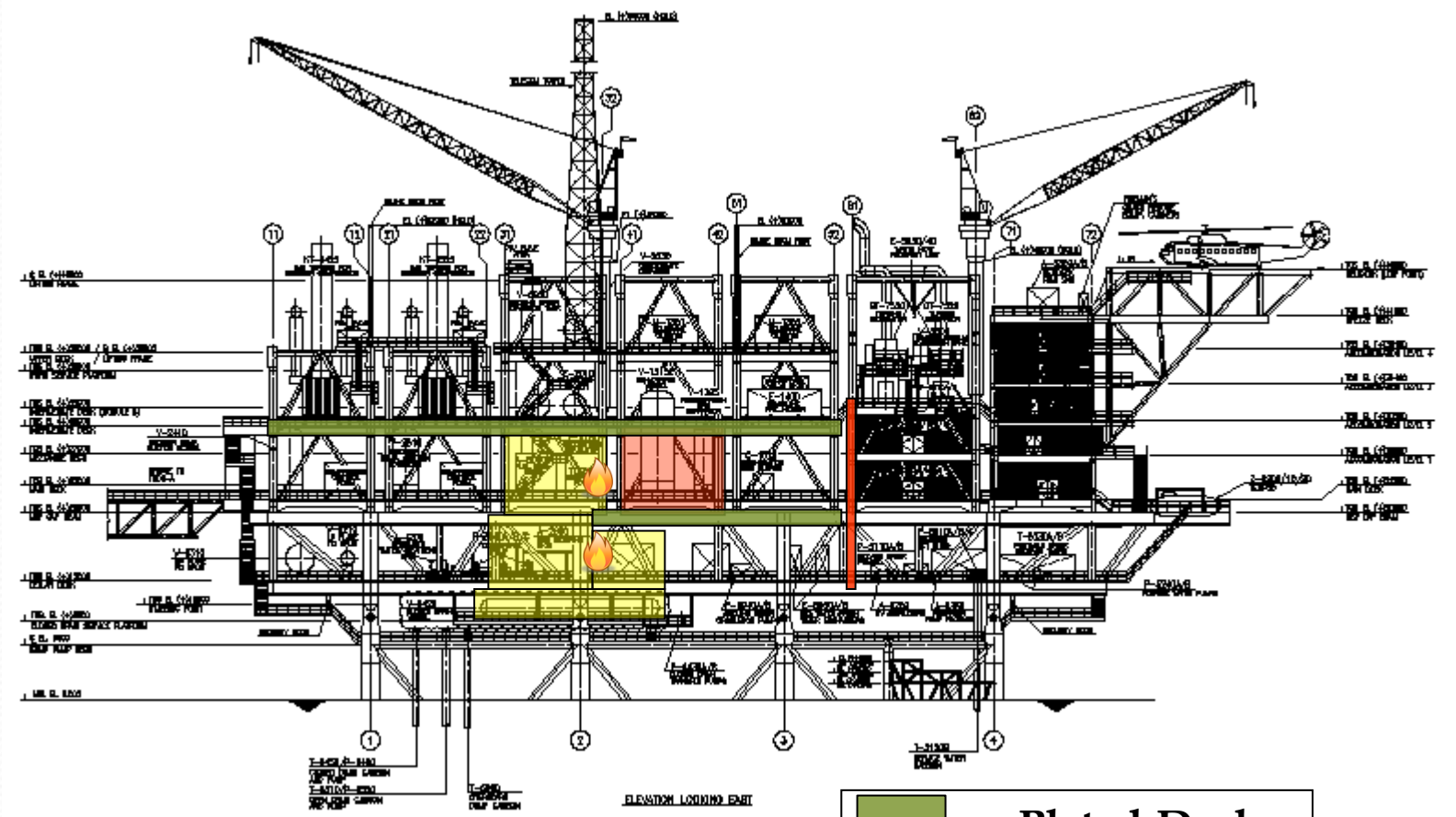

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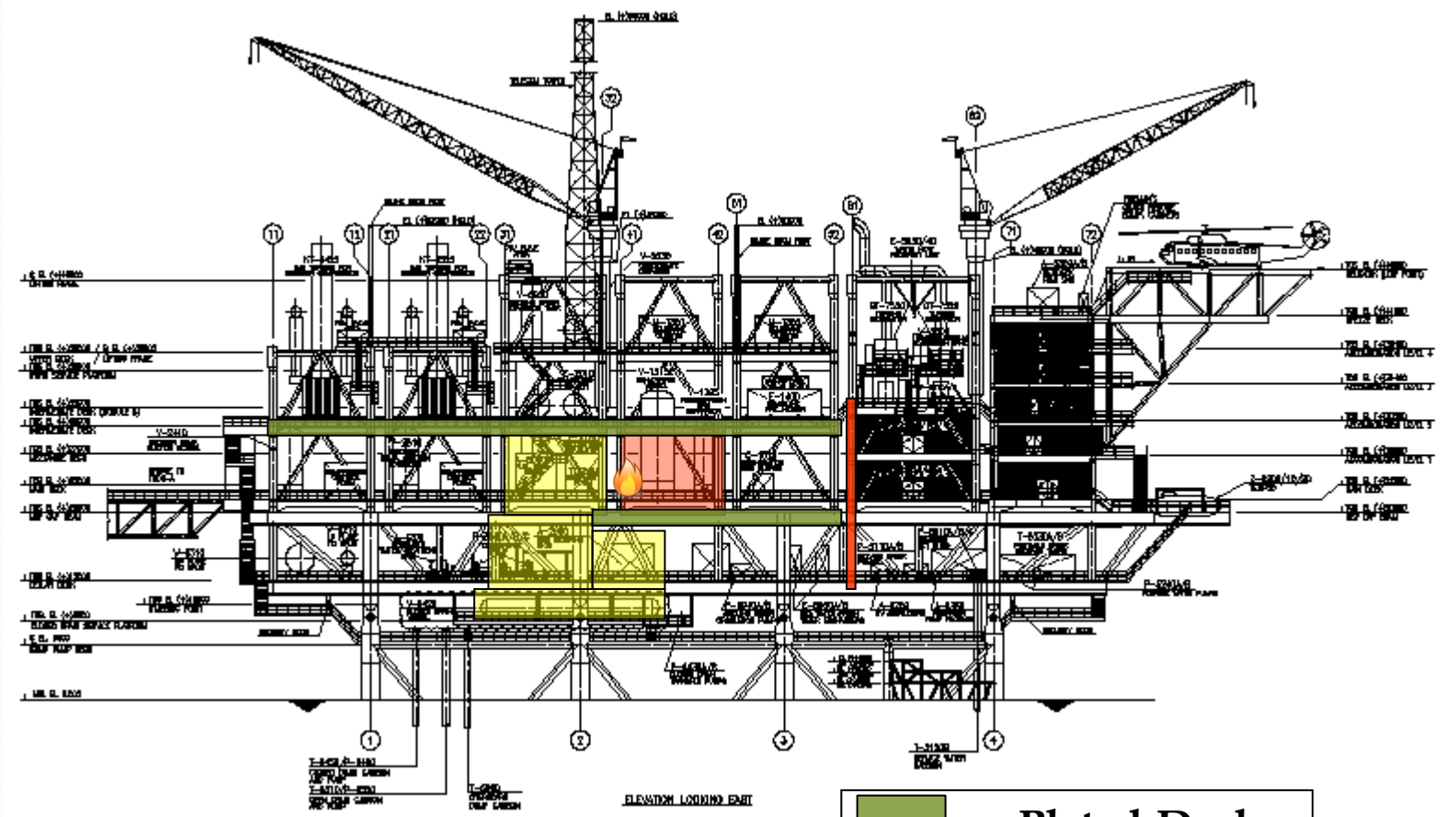

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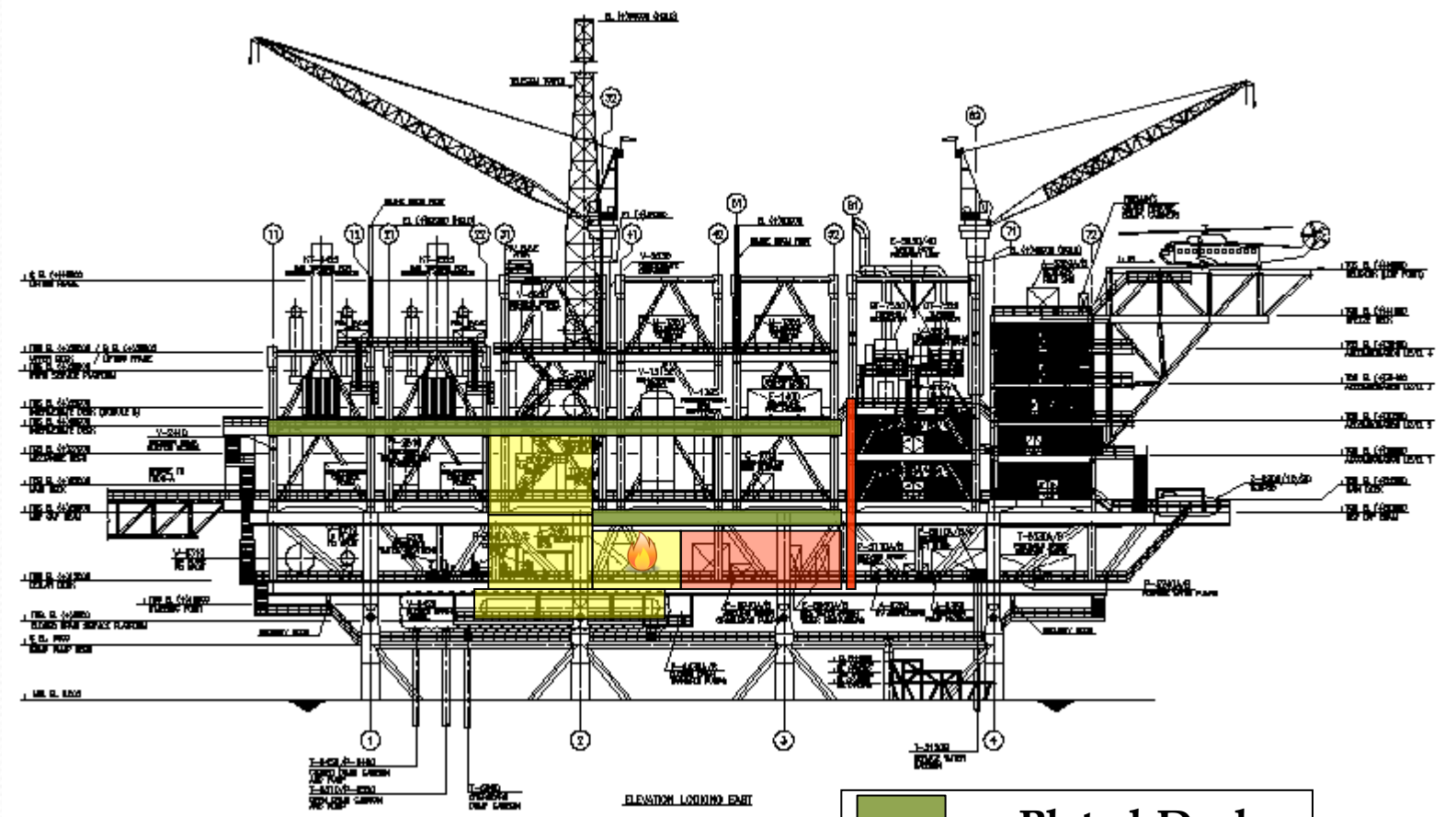

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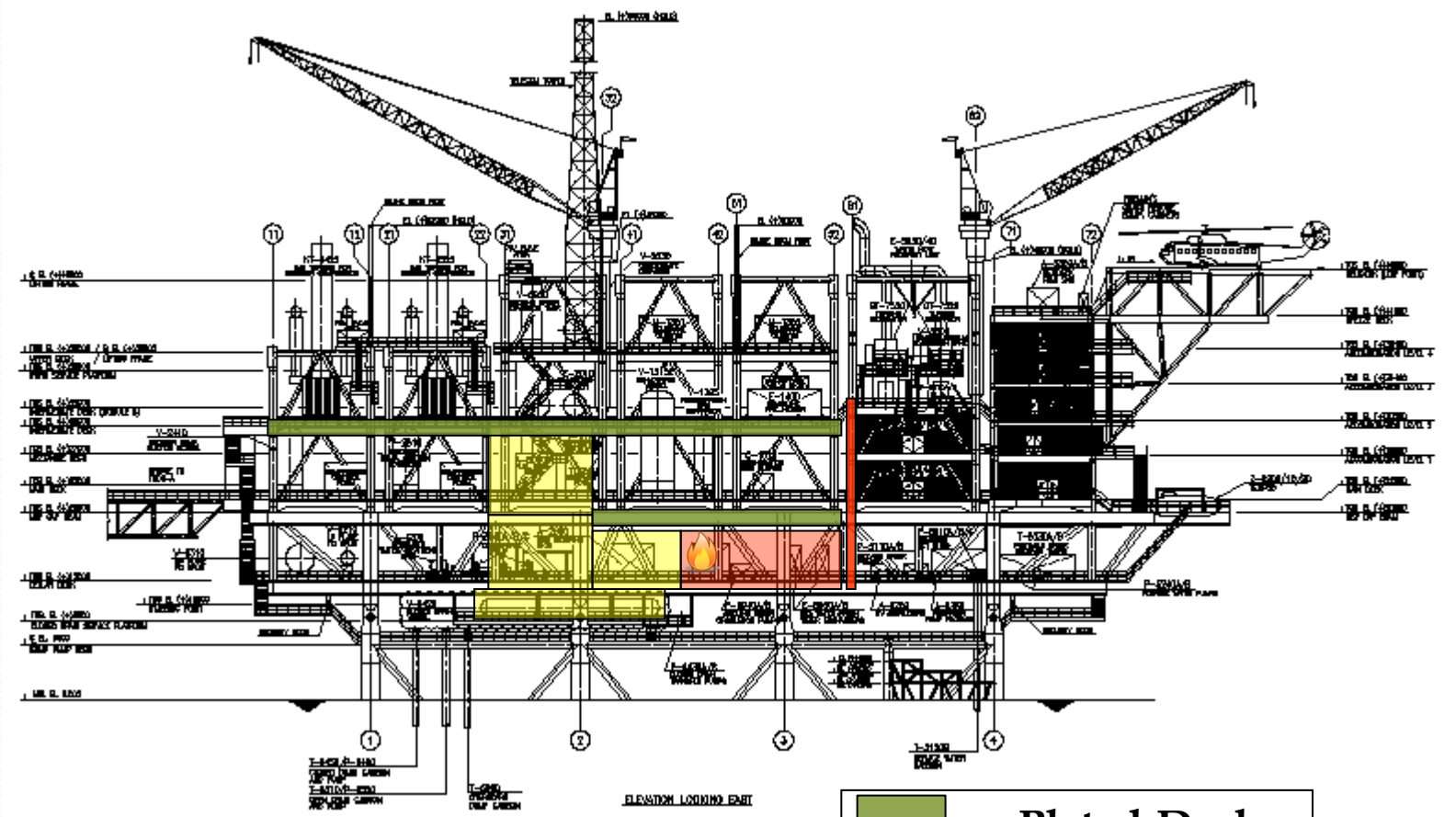

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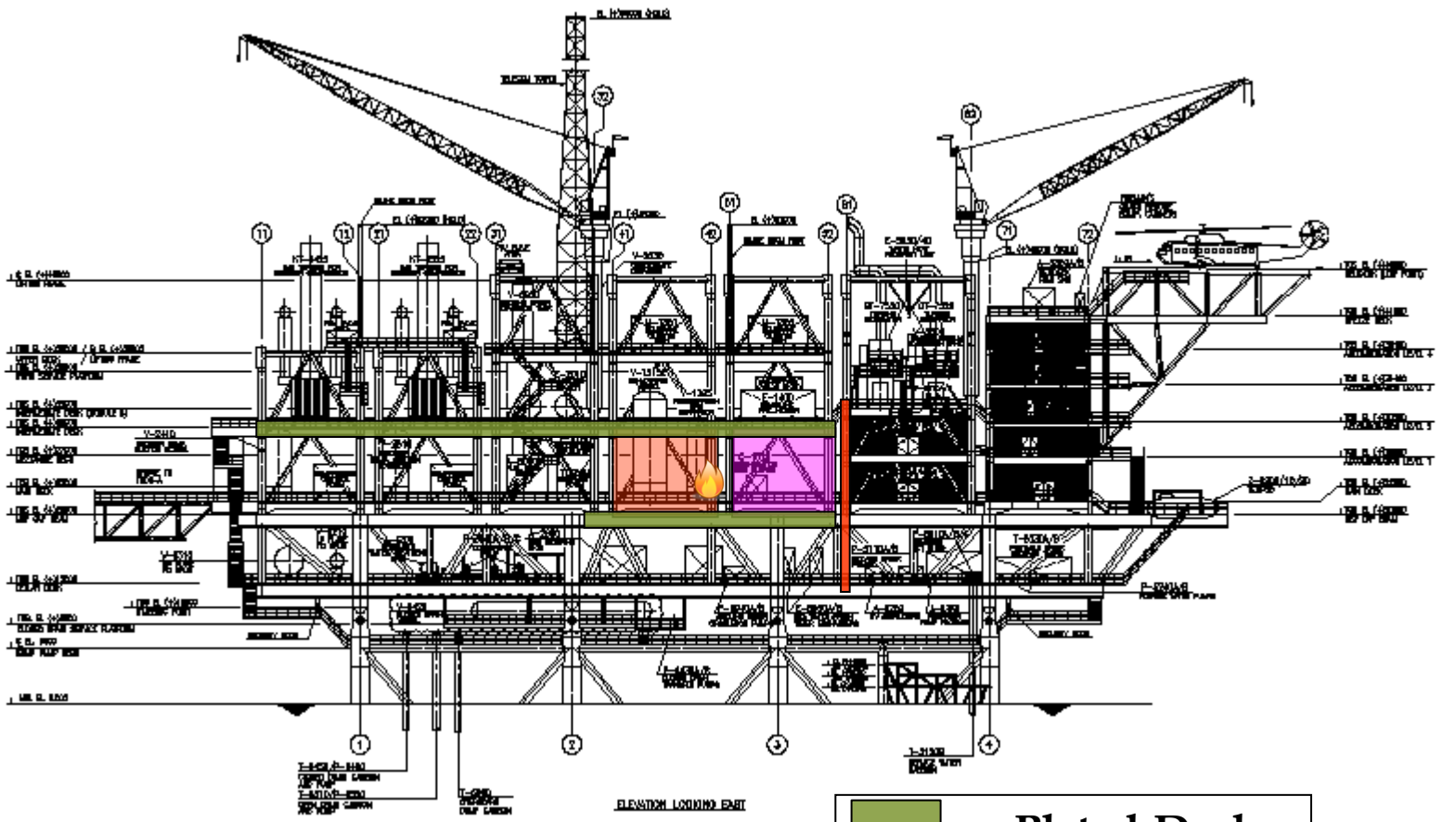

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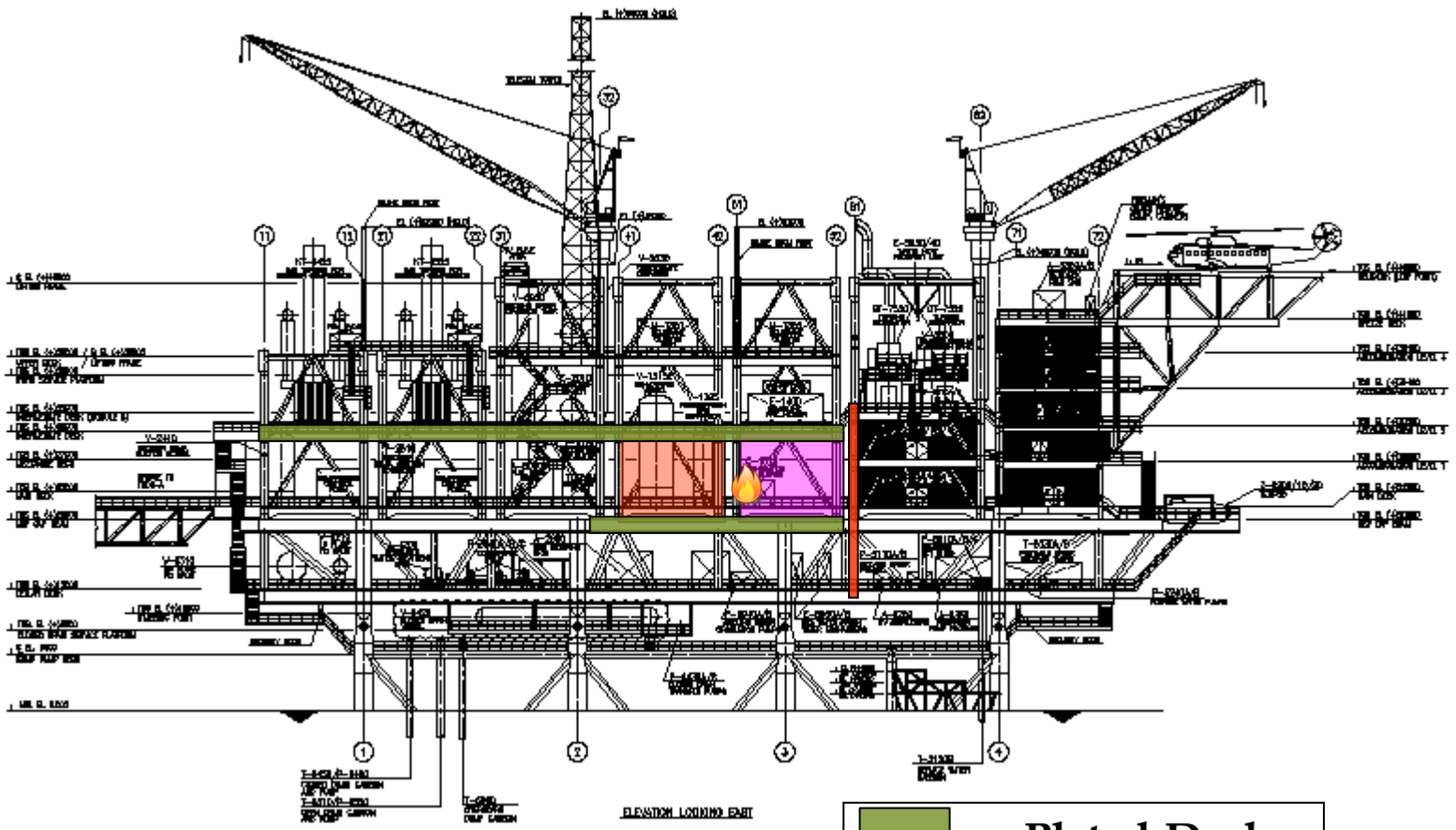

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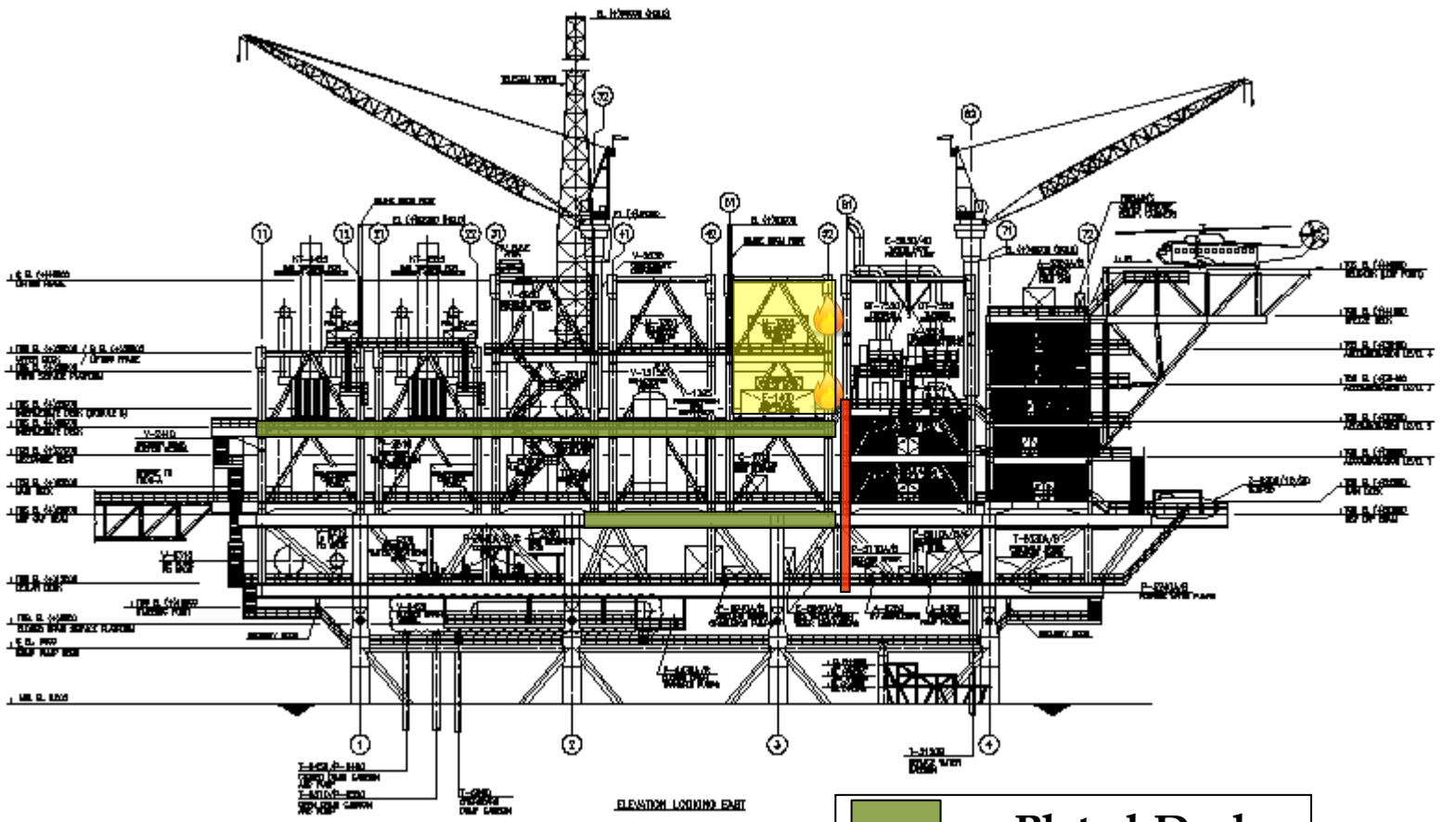

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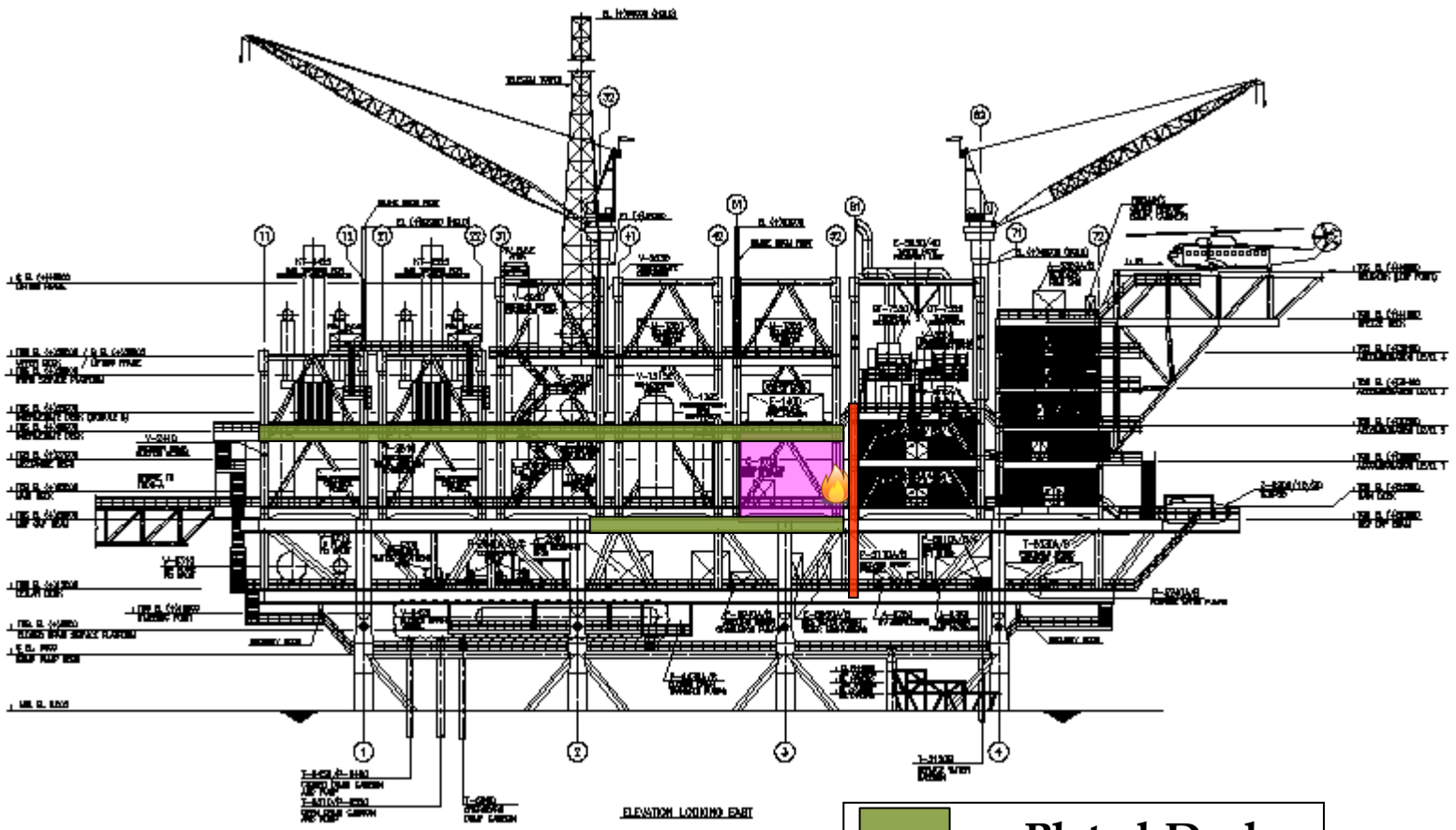

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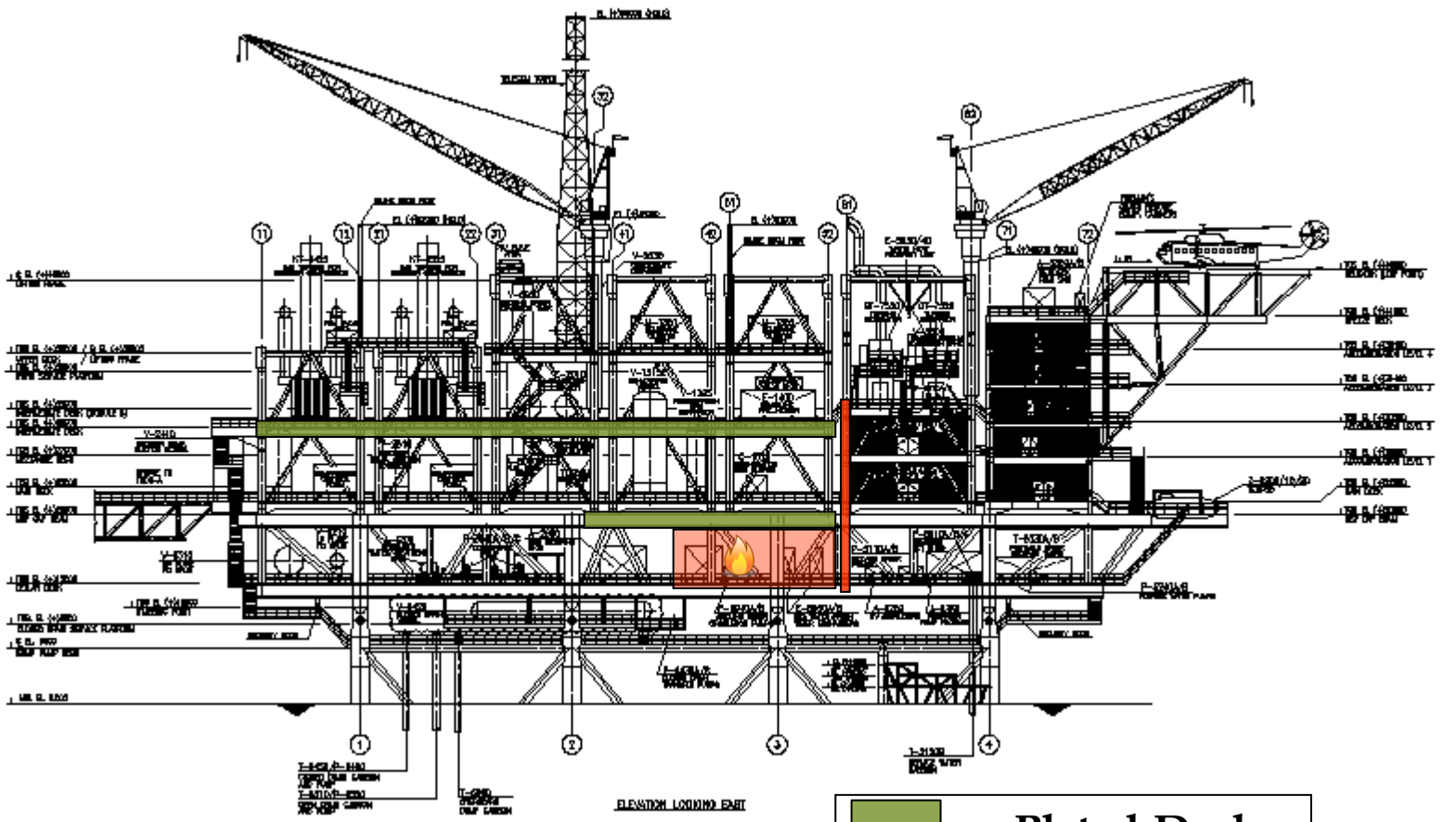

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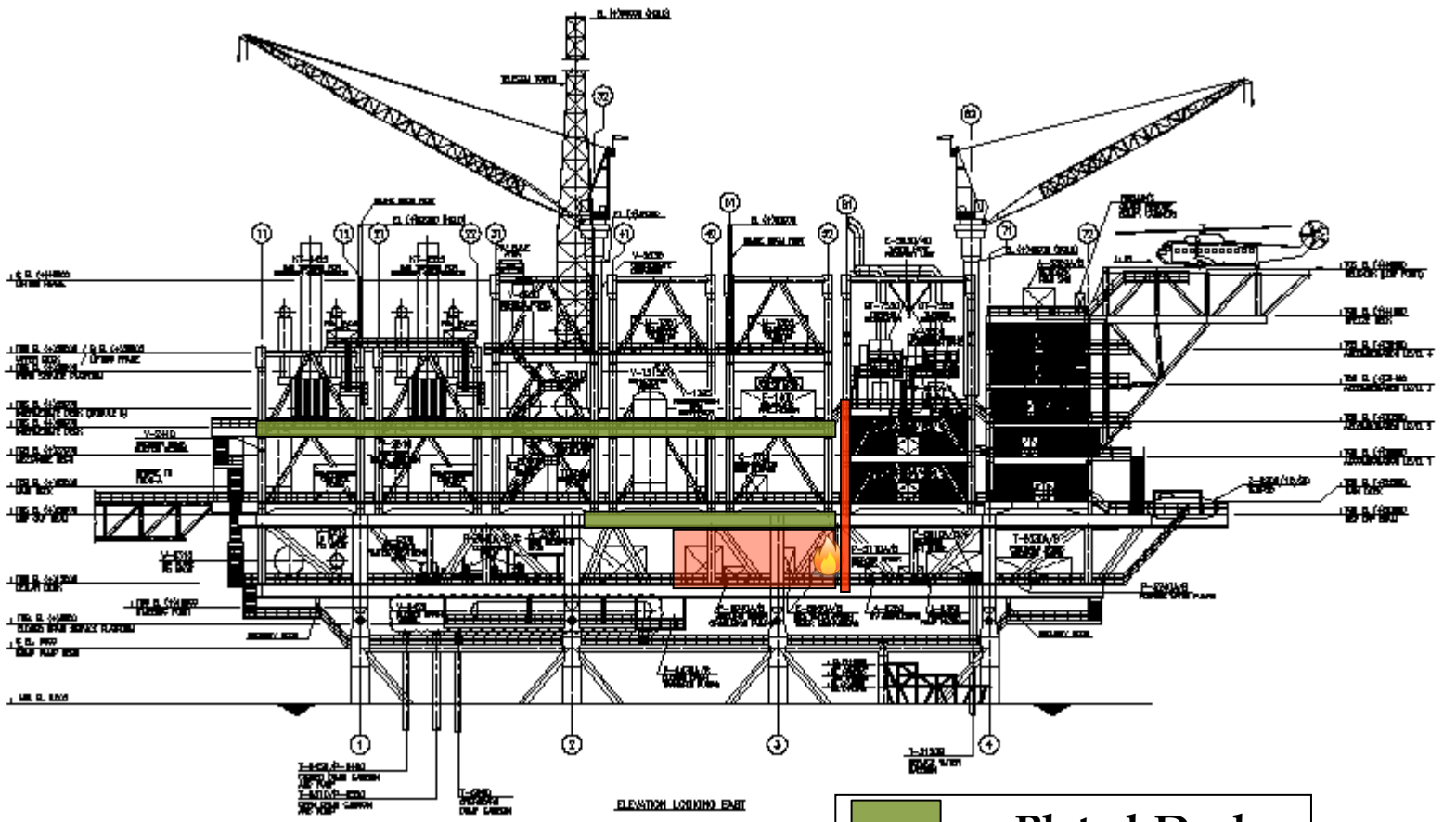


F.I.R.E.W.A.T.E.R D.E.M.A.N.D C.A.L.C.U.L.T.I.O.N.S

DELUGE SYSTEM

- The FW demand is contributed by:
  - The FW demand which will be initiated upon fire detection – deluge consumption
  - Requirement for personnel protection during escape and evacuation / manual fire-fighting by personnel
- Deluge systems are arrays of open head nozzles which are fed from a common valve. The nozzles discharge simultaneously upon opening of the valve.

DELUGE SYSTEM cont'd

- Specific objective of deluge system are:
  - To provide an optimally designed distribution system which delivers water at design rate to spray nozzles
  - To provide a uniform distribution of water at that rate such that the whole area requiring protection is adequately covered.

DELUGE SYSTEM cont'd

- Deluge system may be used effectively for the following applications:
  - Extinguishment – by cooling surface hence reducing vapour emission rate, suppress fire through generation of steam which displace air, dilution of water-soluble flammable liquids, emulsification at the surface of flammable liquids to prevent release of vapour and making the flame unstable thus discontinue the combustion.
  - Control of burning – by reducing the flame temperatures and evaporation rate for pool fires
  - Exposure protection – by limiting the heat transferred to personnel, equipments and structures

DELUGE SYSTEM cont'd

- Deluge water application rates are varies between types of protection, generally range from 6.1 lit/min/m² to 20.4 lit/min/m² (NFPA 15).

7.2.1.3* Design Density. A general range of water spray application rates that shall apply to most ordinary combustible solids or liquids shall be from 6.1 (L/min)/m^2 to 20.4 (L/min)/m^2 (0.15 gpm/ft^2 to 0.50 gpm/ft^2) of protected surface.

DELUGE SYSTEM cont'd

- Table below shows typical deluge application rate for various type of equipment/protection as per PTS 80.47.10.12

Table 8.2 Sprayer selection

EQUIPMENT/AREA	OPEN SPRINKLERS	MEDIUM VELOCITY OPEN SPRAYER	HIGH VELOCITY SPRAYER	MINIMUM WATER APPLICATION RATE
AREA PROTECTION	x			10.2 litres per minute per square metre
WELLHEAD/BOP			x	400 litres per minute per wellhead
PUMPS AND COMPRESSORS		x	x	20.4 litres per minute per square metre
VESSELS AND TANKS		x	x	10.2 litres per minute per square metre
CHEMICAL & AVIATION FUEL STORAGE		x	x	10.2 litres per minute per square metre
PIPELINE		x	x	10.2 litres per minute per square metre
OIL PLATE HEAT EXCHANGERS		x	x	10.2 litres per minute per square metre
STRUCTURAL PROTECTION		x	x	10.2 litres per minute per square metre

DELUGE CONSUMPTION

MODULE 2: BOOSTER COMPRESSOR MODULE

DELUGE VALVE: ADV-5378

COVERAGE AREA: CELLAR DECK & LEVEL 1

As per NFPA 15/ PTS 80.47.10.12

Projection Area = Width x Length

Consumption = Total area x Water rate required

Total surface area for a vessel with 2 heads
= (π x D) L + [2 (1.09 x D2)]

Item No	Equipment		Qty	Rate per Unit Equipment (L/min.m²)	Area per Unit Equipment (m²)	Total Area (m²)	Total Consumption (L/min)
	CELLAR DECK						
					1.70	1.70	34.68
2	3200	4500 mm W x 9264.7 mm L	1	10.20	41.69	41.69	425.25
		mm L	1	10.20	6.00	6.00	61.20
				SUB-TOTAL			521.13
1	BOOSTER COMP. SUCTION SCRUBBER, V-2510	2700 mm ID x 5550 mm T/T	1	10.20	62.97	62.97	642.28
2	BOOSTER COMP. LUBE OIL CONSOLE, E-2550	4000 mm W x 7000 mm L	1	20.40	28.00	28.00	571.20
				SUB-TOTAL			1,213.48
				TOTAL CONSUMPTION FOR ADV-5378			1,734.61

DELUGE CONSUMPTION cont'd

MODULE 2: BOOSTER COMPRESSOR MODULE

DELUGE VALVE: ADV-5378

COVERAGE AREA: CELLAR DECK & LEVEL 1

Item No	Equipment	Dimension	Qtty	Water Rate Required (L/min.m^2)	Area per Unit Equipment (m^2)	Total Area (m^2)	Total Consumption (L/min)
	CELLAR DECK						
1	CONDENSATE PUMP, P-3040A	1000 mm W x 1700 mm L	1	20.40	1.70	1.70	34.68
2	CONDENSATE METERING SKID, A-3200	4500 mm W x 9264.7 mm L	1	10.20	41.69	41.69	425.25
3	PRODUCED WATER TREATMENT SKID, A-4200	2000 mm W x 3000 mm L	1	10.20	6.00	6.00	61.20
				SUB-TOTAL			**521.13**
	LEVEL 1						
1	BOOSTER COMP. SUCTION SCRUBBER, V-2510	2700 mm ID x 5550 mm T/T	1	10.20	62.97	62.97	642.28
2	BOOSTER COMP. LUBE OIL CONSOLE, E-2550	4000 mm W x 7000 mm L	1	20.40	28.00	28.00	571.20
				SUB-TOTAL			**1,213.48**
				TOTAL CONSUMPTION FOR ADV-5378			**1,734.61**

DELUGE CONSUMPTION cont'd

- Summary of deluge consumptions are tabulated below:

No.	Area to be Deluged / Spray	ADV Tag No	Deluge Consumption
1	Module 1 Level 2	ADV-5370	2186.44 lit/min
2	Module 1 Level 1 and Cellar Deck	ADV-5373	3137.70 lit/min
3	Module 2 Level 2	ADV-5375	2186.44 lit/min
4	Module 2 Level 1 and Cellar Deck	ADV-5378	1952.78 lit/min
5	Module 3 Level 2 and Level 3	ADV-5380	1489.78 lit/min
6	Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	ADV-5383	4155.69 lit/min
7	Module 4 Level 2 and Level 3	ADV-5385	4674.55 lit/min
8	Module 4 Level 1	ADV-5388	4918.37 lit/min
9	Module 5 Level 3 and Level 2	ADV-5390	7189.23 lit/min
10	Module 5 Level 1	ADV-5393	3756.50 lit/min
11	Module 5 Cellar Deck and Module 4 Cellar Deck South Side	ADV-5398	837.57 lit/min

FW DEMAND CALCULATIONS

- FW demand by deluge system for each major fire scenario.

No.	Scenarios	Area to be Deluged / Spray	Firewater Demand	
1	Fire in module 1 Level 2 (North Side)	1. Module 1 Level 2	2186.44 lit/min	
		Sub-Total	**2186.44 lit/min**	**= 131.19 m³/hr**
2	Fire in module 1 Level 2 (South Side)	1. Module 1 Level 2	2186.44 lit/min	
		2. Module 2 Level 2	2186.44 lit/min	
		Sub-Total	**4372.44 lit/min**	**= 262.38 m³/hr**
3	Fire in module 1 Level 1 or Cellar Deck (North Side)	1. Module 1 Level 1 and Cellar Deck	3137.70 lit/min	
		Sub-Total	**3137.70 lit/min**	**= 188.26 m³/hr**
4	Fire in module 1 Level 1 or Cellar Deck (South Side)	1. Module 1 Level 1 and Cellar Deck	3137.70 lit/min	
		2. Module 2 Level 1 and Cellar Deck	1952.78 lit/min	
		Sub-Total	**5090.48 lit/min**	**= 305.43 m³/hr**
5	Fire in module 2 Level 2 (North Side)	1. Module 1 Level 2	2186.44 lit/min	
		2. Module 2 Level 2	2186.44 lit/min	
		Sub-Total	**4372.44 lit/min**	**= 262.38 m³/hr**
6	Fire in module 2 Level 2 (South Side)	1. Module 2 Level 2	2186.44 lit/min	
		2. Module 3 Level 2 and Level 3	1489.78 lit/min	
		Sub-Total	**3676.22 lit/min**	**= 220.57 m³/hr**

FW DEMAND CALCULATIONS cont'd

- Major fire scenario table continued.

No.	Scenarios	Area to be Deluged / Spray	Firewater Demand	
7	Fire in module 2 Level 1 or Cellar Deck (North Side)	1. Module 2 Level 1 and Cellar Deck	1952.78 lit/min	
		2. Module 1 Level 1 and Cellar Deck	3137.70 lit/min	
		Sub-Total	**5090.48 lit/min**	**= 305.43 m^3/hr**
8	Fire in module 2 Level 1 or Cellar Deck (South Side)	1. Module 2 Level 1 and Cellar Deck	1952.78 lit/min	
		2. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.69 lit/min	
		Sub-Total	**6108.47 lit/min**	**= 366.51 m^3/hr**
9	Fire in module 3 Level 3 or Level 2 (North Side)	1. Module 3 Level 2 and Level 3	1489.78 lit/min	
		2. Module 2 Level 2	2186.44 lit/min	
		Sub-Total	**3676.22 lit/min**	**= 220.57 m^3/hr**
10	Fire in module 3 Level 3 or Level 2 (South Side)	1. Module 3 Level 2 and Level 3	1489.78 lit/min	
		2. Module 4 Level 2 and Level 3	4674.55 lit/min	
		Sub-Total	**6164.33 lit/min**	**= 369.86 m^3/hr**
11	Fire in Module 3 Level 1 or Cellar Deck (North Side)	1. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.69 lit/min	
		2. Module 2 Level 1 and Cellar Deck	1952.78 lit/min	
		Sub-Total	**6108.47 lit/min**	**= 366.51 m^3/hr**

FW DEMAND CALCULATIONS cont'd

- Major fire scenario table continued.

No.	Scenarios	Area to be Deluged / Spray	Firewater Demand	
12	Fire in Module 3 Level 1 or Cellar Deck (South Side)	1. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.69 lit/min	
		2. Module 4 Level 1	4918.37 lit/min	
		Sub-Total	**9074.06 lit/min**	**= 544.44 m^3/hr**
13	Fire in module 4 Level 3 or Level 2 (North Side)	1. Module 4 Level 2 and Level 3	4674.55 lit/min	
		2. Module 3 Level 2 and Level 3	1489.78 lit/min	
		Sub-Total	**6164.33lit/min**	**= 369.86 m^3/hr**
14	Fire in module 4 Level 3 or Level 2 (South Side)	1. Module 4 Level 2 and Level 3	4674.55 lit/min	
		2. Module 5 Level 2 and Level 3	7189.23 lit/min	
		Sub-Total	**11863.78 lit/min**	**= 711.83 m^3/hr**
15	Fire in module 4 Level 1 (North Side)	1. Module 4 Level 1	4918.37 lit/min	
		2. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.69 lit/min	
		Sub-Total	**9074.06 lit/min**	**= 544.44 m^3/hr**
16	Fire in module 4 Level 1 (South Side)	1. Module 4 Level 1	4918.37 lit/min	
		2. Module 5 Level 1	3756.50 lit/min	
		Sub-Total	**8674.87 lit/min**	**= 520.49 m^3/hr**

FW DEMAND CALCULATIONS cont'd

- Major fire scenario table continued.

No.	Scenarios	Area to be Deluged / Spray	Firewater Demand	
17	Fire in module 4 Cellar Deck (North Side)	1. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.67 lit/min	
		2. Module 5 Cellar Deck and Module 4 Cellar Deck South Side	837.57 lit/min	
		Sub-Total	**4993.24 lit/min**	**= 299.59 m³/hr**
18	Fire in module 4 Cellar Deck (South Side)	1. Module 5 Cellar Deck and Module 4 Cellar Deck South Side	837.57 lit/min	
		2. Module 3 Level 1 and Cellar Deck and Module 4 Cellar Deck North Side	4155.67 lit/min	
		Sub-Total	**4993.24 lit/min**	**= 299.59 m³/hr**
19	Fire in module 5 Level 3 or Level 2 (North Side)	1. Module 5 Level 3 and Level 2	7189.23 lit/min	
		2. Module 4 Level 2 and Level 3	4674.55 lit/min	
		Sub-Total	**11863.78 lit/min**	**= 711.83 m³/hr**
20	Fire in module 5 Level 3 or Level 2 (South Side)	1. Module 5 Level 3 and Level 2	7189.23 lit/min	
		Sub-Total	**7189.23 lit/min**	**= 431.35 m³/hr**
21	Fire in module 5 Level 1 (North Side)	1. Module 5 Level 1	3756.50 lit/min	
		2. Module 4 Level 1	4918.37 lit/min	
		Sub-Total	**8674.87 lit/min**	**= 520.49 m³/hr**

FW DEMAND CALCULATIONS cont'd

- Major fire scenario table continued.

No.	Scenarios	Area to be Deluged / Spray	Firewater Demand	
22	Fire in module 5 Level 1 (South Side)	1. Module 5 Level 1	3756.50lit/min	
		Sub-Total	**3756.50 lit/min**	**= 225.39 m^3/hr**
23	Fire in module 5 Cellar Deck (North Side)	1. Module 5 Cellar Deck and Module 4 Cellar Deck South Side	837.57 lit/min	
		Sub-Total	**837.57 lit/min**	**= 50.25 m^3/hr**
24	Fire in module 5 Cellar Deck (South Side)	1. Module 5 Cellar Deck and Module 4 Cellar Deck South Side	837.57 lit/min	
		Sub-Total	**837.57 lit/min**	**= 50.25 m^3/hr**
25	**Fire in Helideck Area**	1. 2 Foam monitors		460.00 m^3/hr
		Sub-Total		**460.00 m^3/hr**
26	**Fire at TBDR-A**	1. Wellhead Area (21 Slots)	8400.00 lit/min	
		2. TBDR-A Slug Catcher	2717.16 lit/min	
		Sub-Total	**11117.16 lit/min**	**= 667.03 m^3/hr**

FW DEMAND CALCULATIONS cont'd

- Maximum FW demand for deluge system are 711.83 m^3/hr
- 2 FW monitors considered to be used for personnel protection during evacuation
- Rated capacity for each monitor of 120 m^3/hr @ 7.0 barg (100 psig) is specified for this case. This is as per PTS 80.47.10.12:

> flow capacity (typically monitor nozzles have a throughput in the order of 1500 to 2000 l/min at a minimum operating pressure of 7 bar (ga);

FW DEMAND CALCULATIONS cont'd

From the table, the max. anticipated firewater demand for single major fire scenario occur during scenario 14 and 19.

➢ Maximum demand for deluge	= 711.83	m^3/hr
➢ 15% margin added for hydraulic balance	= 711.83 x 1.15 = 818.60 m^3/hr	m^3/hr
➢ 2 monitors used for personnel protection	= 2 x 120 m^3/hr = 240	m^3/hr
➢ Hence, total firewater demand	= 818.60 + 240 = 1058.60	m^3/hr m^3/hr
➢ FW pump rated capacity	**≈ 1100**	**m^3/hr**

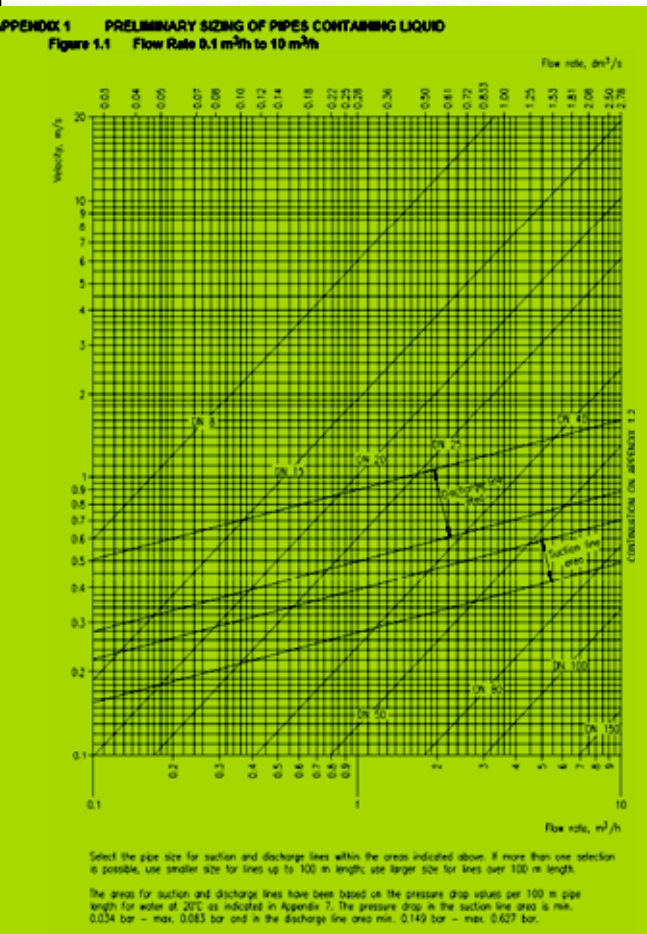
PRELIMINARY PIPE SIZING

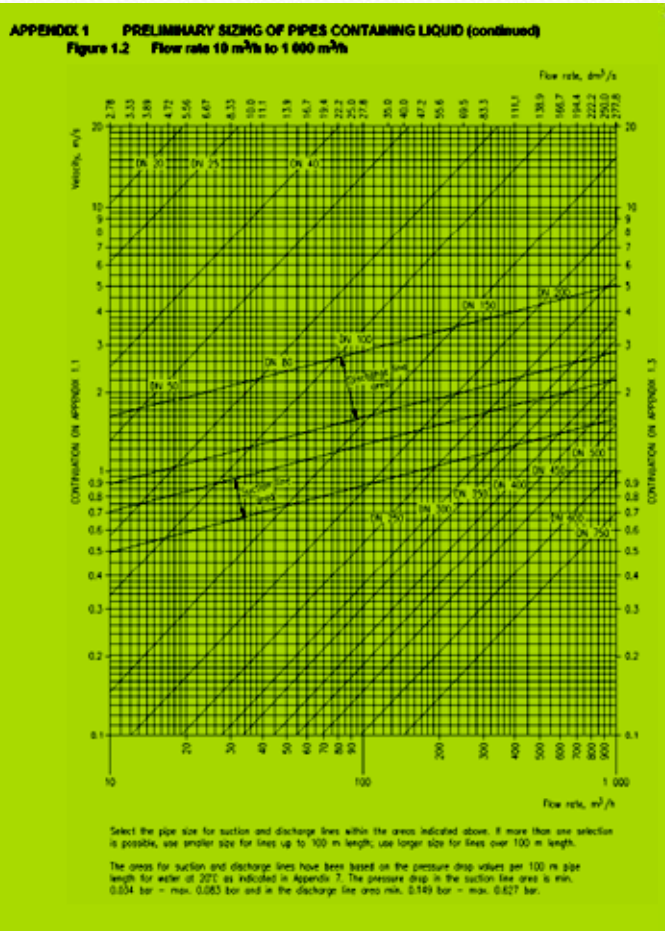
- Objectives: To provide preliminary line size estimation for main pipeworks in FW system e.g. FW pump discharge, ringmain, risers and deluge pipings.
- The preliminary line sizing is established using Preliminary Line Sizing Chart provided in P.T.S 31.38.01.11-Appendix A.
- These line sizes will be verified using software during hydraulic analysis

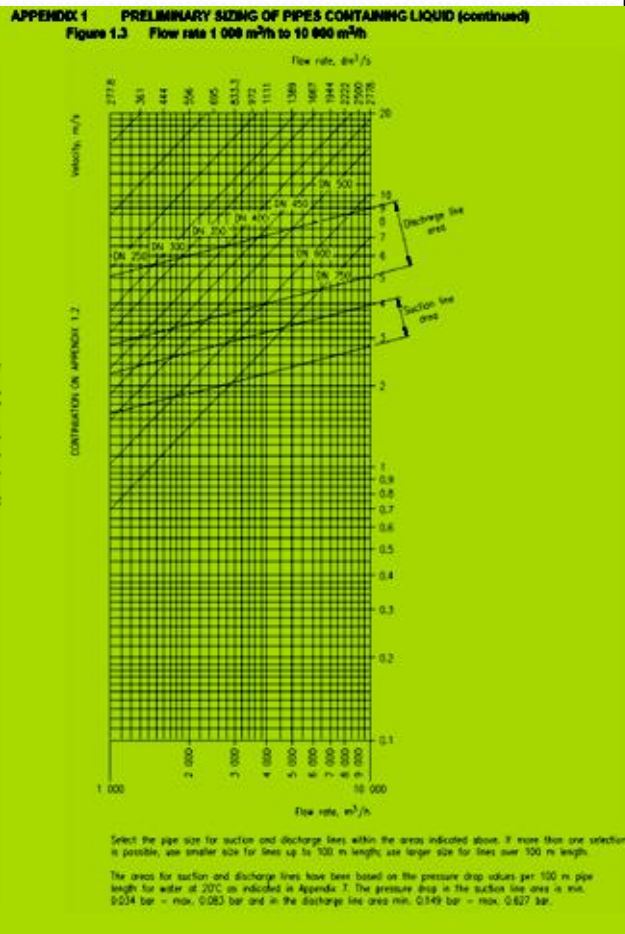
PRELIMINARY PIPE SIZING

cont'd

- Prelim. line sizing for water extracted from P.T.S 31.38.01.11







PRELIMINARY PIPE SIZING cont'd

- If more than one selection is possible, smaller size should be for lines up to 100m length; while larger lines size for length over 100m.
- Sample of results are tabulated below:

Line Segment	Flowrate (m^3/hr)	Pipe Size (mm)
Pump discharge line	1650	DN350
Ringmain	1650	DN350
M1, East side riser	≈240	DN200
M1, West side riser	≈147	DN150
M2, East side riser	≈240	DN200
M2, West side riser	≈147	DN150

FW PUMP SIZING

- Objective :
  i. To determine the required FW pump discharge pressure.
- Basis :
  i. FW pump discharge head characteristic shall be sufficient to meet all firewater system pressure demands plus losses within distribution system – to meet 100 psig at the most hydraulically remote FW monitor/other firefighting equipment.
  ii. Pressure drop is calculated using *Hazen-Williams formula*.
  iii. 50% additional margin of pipe length is included to the calculated straight length of the pipe to cater for fittings and bends.
  iv. Maximum pressure drop across helideck foam skid is taken as 1 bar.

FW PUMP SIZING cont'd

- FW pump disch press = $P_{@remote\ monitor} + \Delta P_{total\ static\ head} + \Delta P_{helideck\ foam\ skid} + \Delta P_{friction\ loss}$

$P_{@remote\ monitor}$ = 7.0 barg (100 psig)

total static head = $\rho_{fw}\, gh$

$\Delta P_{helideck\ foam\ skid}$ = 1.0 bar

$\Delta P_{friction\ loss}$ = $\rho_{fw}\, H_{L1}$

- The *Hazen-Williams formula* is expressed as:

$$\text{Head loss, } H_{L1} = 0.015\ (Q^{1.85}\ L\ /\ d_i^{4.87}\ C^{1.85})$$

Where Q is firewater flowrate, bpd

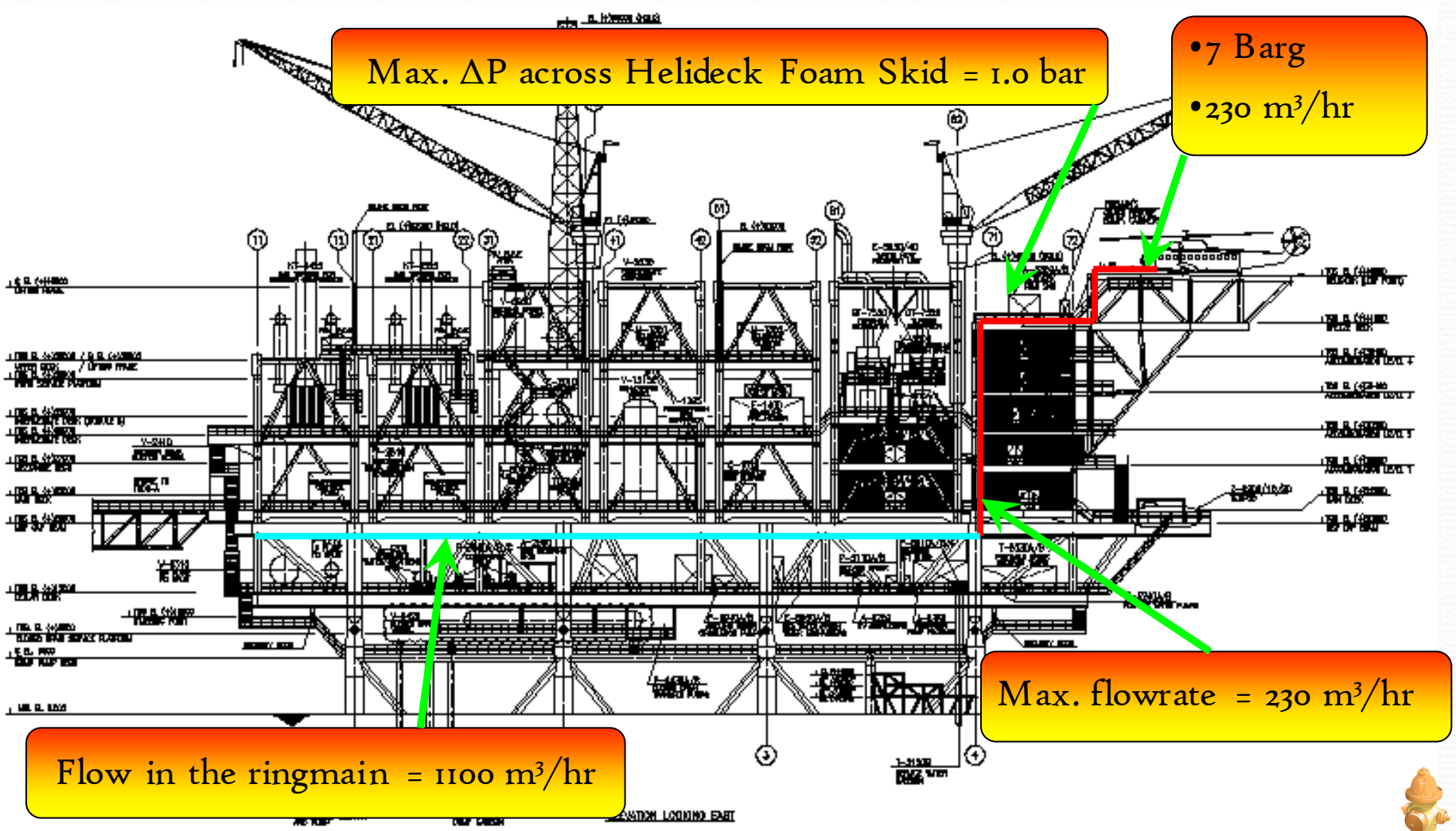
L is the length of pipe, ft

d_i is the internal diameter, in

C is Hazen-Williams constant, dimensionless

H_{L1} is the head loss

FW PUMP SIZING cont'd



FW PUMP SIZING cont'd

- FW pump discharge pressure:

$$
\begin{aligned}
P_{\text{@remote monitor}} &= 7.0 && \text{barg} \\
\text{total static head} &= \rho_{fw}\, gh && \text{bar} \\
&= 2.7 && \text{bar} \\
\Delta P_{\text{helideck foam skid}} &= 1.0 && \text{bar} \\
\Delta P_{\text{friction loss}} &= 0.22 && \text{bar} \\
\\
P_{\text{FW disch}} &= 7.0 + 3.4 + 1.0 + 0.22 && \text{barg} \\
&= 10.9 && \text{barg} \\
&\approx 11.0 && \text{barg}
\end{aligned}
$$

- ∴ Each FW pump shall have capability to deliver reliable FW supply of 1100 m^3/hr rated flowrate @ flange discharge pressure of 11.0 barg.
- In addition, as per NFPA 20, each FW pump shall have maximum capacity of not less than 150% rated capacity @ discharge head of not less than 65% of discharge at rated capacity.

FW PUMP SIZING cont'd