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HIPPS

(High Integrity Pressure Protection System)

Engineering GREAT Solutions

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Control & Safety Systems Technology Manager, FS Eng (TUV Rheinland, #1977/09, SIS)
IMI CCI

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HIPPS

HIPPS Applications

CCI HIPPS Technology Belongs to IMI Critical Engineering (Previously 'IMI Severe Service')

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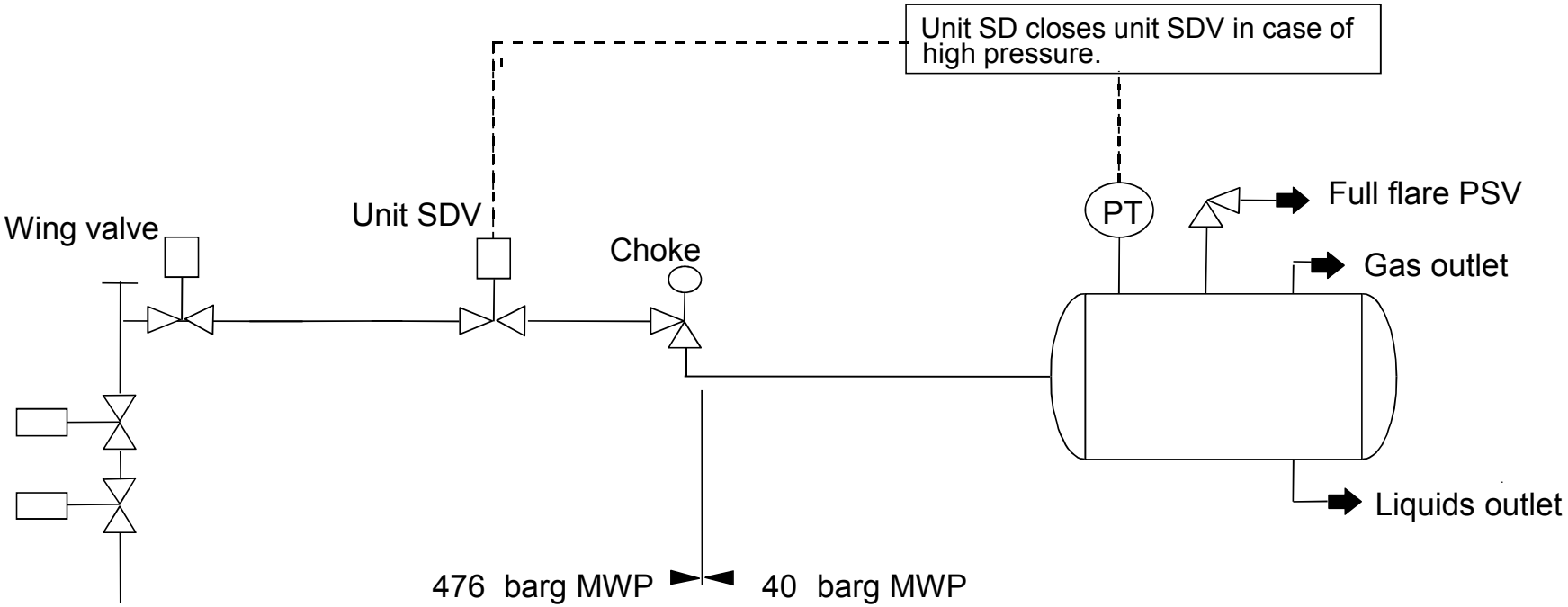
Where can HIPPS be used

- **Well Control, flow-lines (reduced wall thickness)**
- **Inlet of separators and Slug Catchers**
- **Pressure let down stations**
- **Gas Injection Compressor Facilities**
- **Loss of cooling medium / power in downstream processes like propane circuit, refrigeration circuits, distillation columns, amine re-boilers.**
- **Reduced Flare Systems**
- **Where flaring/venting is not possible**

Example arrangement

Production Separator with PSV

API Recommended Practice 14C



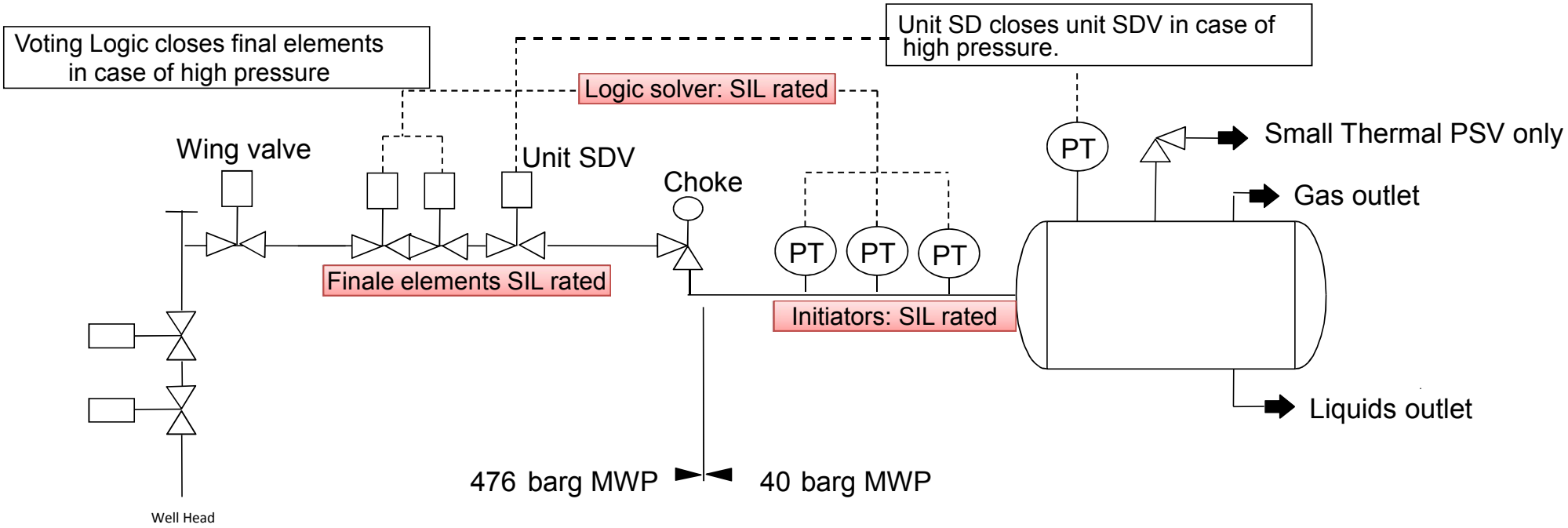
- The outlet of the separator blocks,
- The choke does not close (1° failure),
- The Unit SDV does not close (2° failure),
- The PSV open and discharge the full flow to flare.

Consequence: the PSV is sized for **full flow** of the well. Flare system is necessary.

Example arrangement

Production Separator with HIPPS

API Recommended Practice 14C

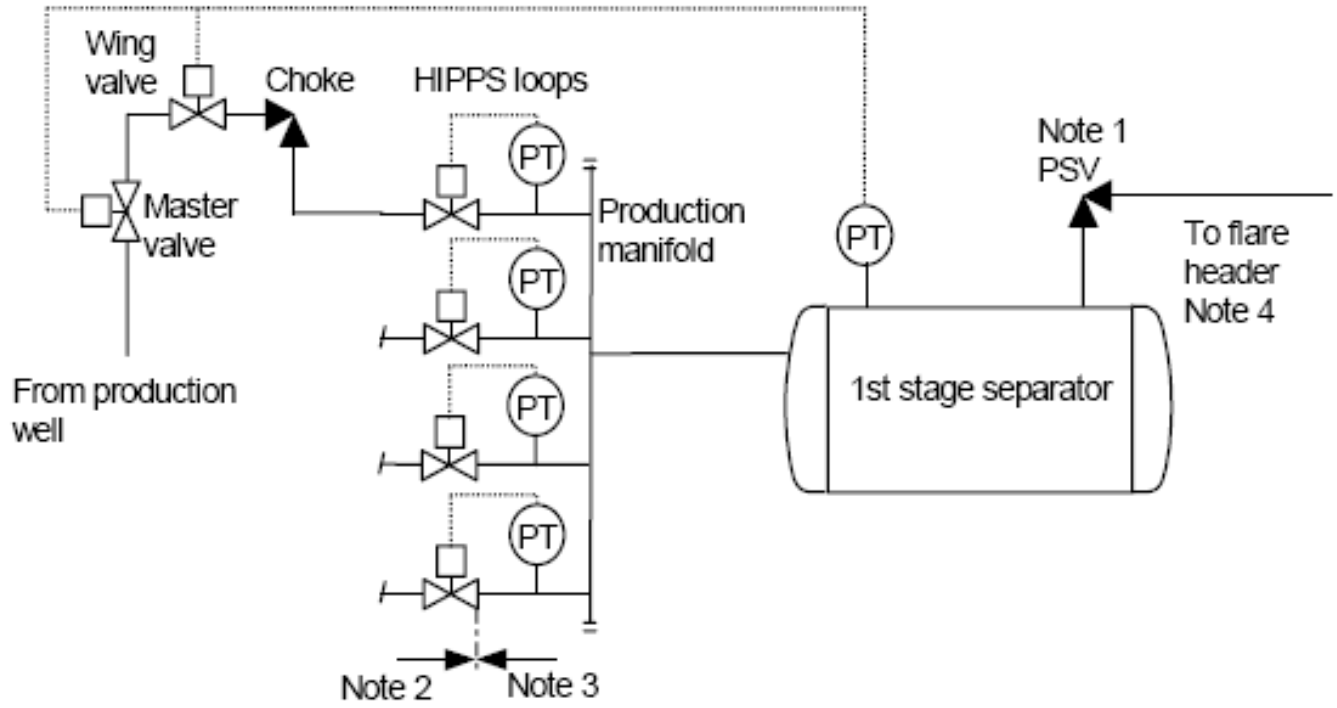


- The outlet of the separator blocks,
- The choke does not close (1° failure),
- The Unit SDV does not close (2° failure),
- The HIPPS shall close in 2 seconds to avoid overpressure in the separator.

BENEFIT: the PSV is sized for thermal relief/leakage only. Flare system is avoided.

Example arrangement

Other example of an arrangement where the PSV capacity is reduced by the use of the HIPPS



Notes:
1. PSV including piping designed for blocked outlets and failure of two HIPPS loops
2. Designed for well shut in pressure
3. Separator design pressure
4. Flare header with sufficient capacity to accept failure in two HIPPS loops

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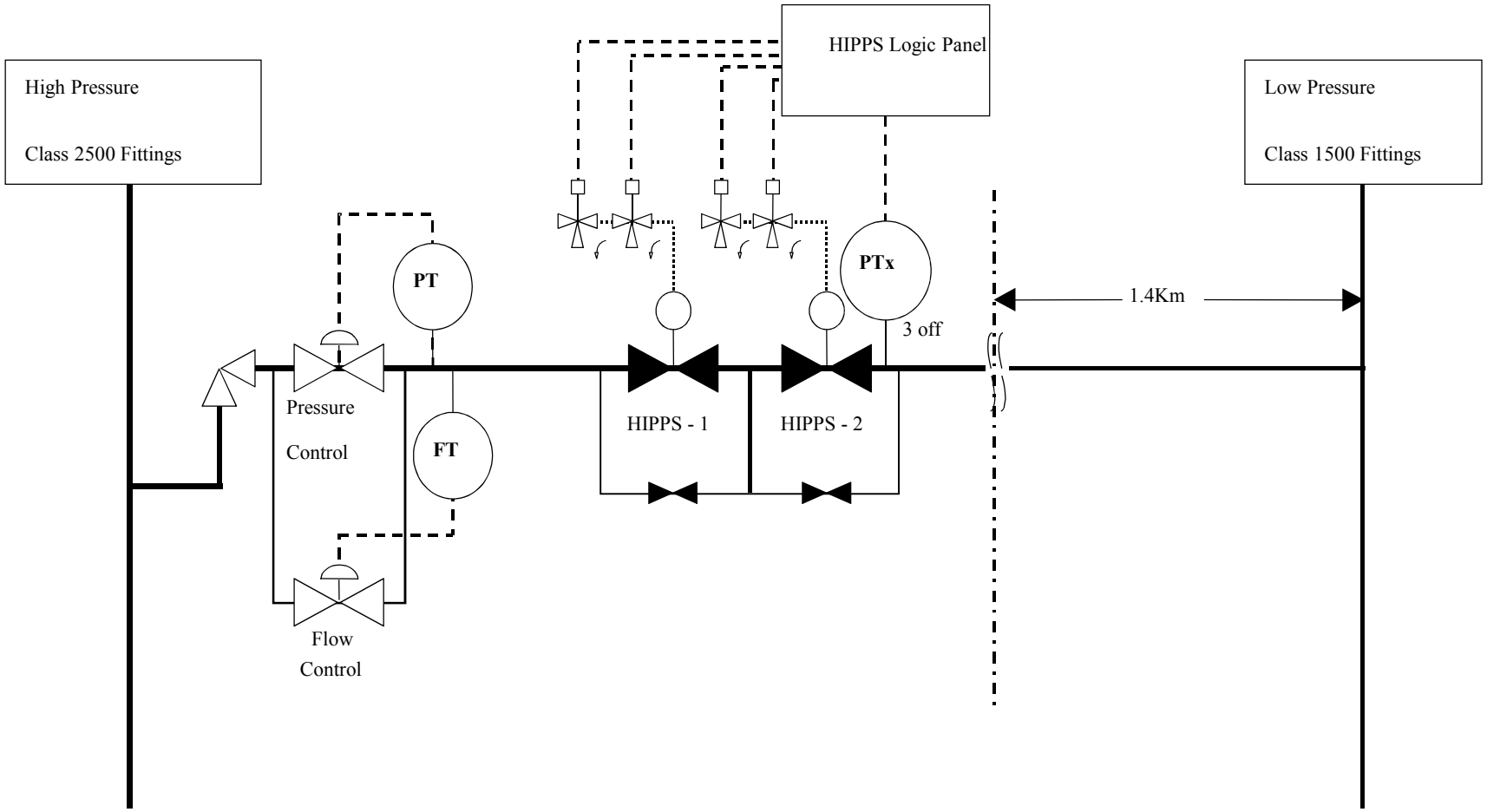
Example arrangement

HIPPS in transferring of gas from one pipeline header to another



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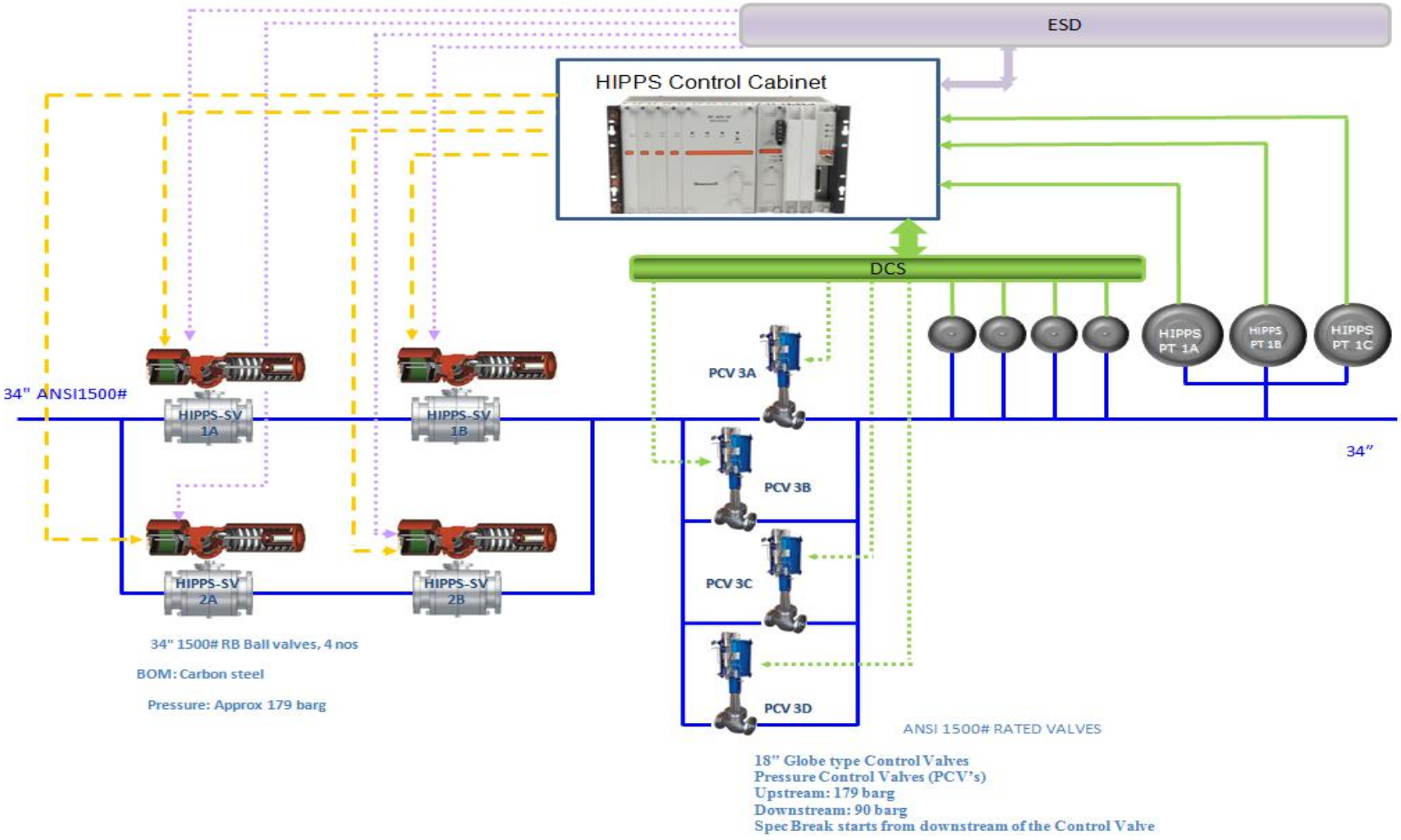
Example arrangement

HIPPS in LNG Liquefaction System



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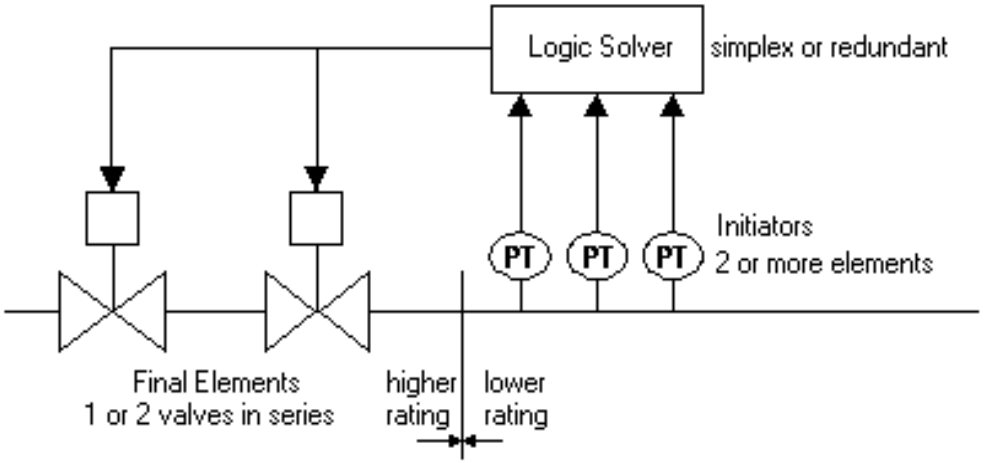
HIPPS Design

HIPPS composition



HIPPS is composed by the following main subsystems: Initiators; Logic Solver; Final Elements.

- Initiators: The elements measuring the (over) pressure.
- Logic Solver: Safety system that receives the signals from the initiators, performs the required logics and drives the final elements.
- Final Elements: On/Off valves provided with actuators, solenoids and limit switches. Typically valves close to isolates the dangerous pressure source and protect the downstream lines.

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Initiators

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Initiators are the elements measuring the process pressure.

The initiators can be:

Pressure switches

- ***Pro**: it can be used for system up to SIL 4*
- ***Con**: no diagnostic, no pressure measurement but only reacts when the trip limit has been reached*

Pressure transmitters

- ***Pro**: continuous reading of the pressure, diagnostic information because it is microprocessor based*
- ***Con**: up to SIL 3 in multiple configuration*

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Logic Solver

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Final Element - Valves

Feature	Ball Valve 	Gate Valve 	Axial Valve 
Pressure Loss	Full Bore No pressure loss	Full Bore No pressure loss	Similar to Globe Valve
Flow direction	Bidirectional	Bidirectional	Unidirectional
Maintenance	On-Line available for top entry solution. Maintenance is anyway easy because of product simplicity. Full Bore “piggable”	On-Line available for non-compact Actuators. Maintenance is anyway easy because of product simplicity. Full Bore “piggable”	Off-line only because of split body design. Not easy to clean. Motion conversion system can be tricky. Not “piggable”

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Partial Stroke Test

PARTIAL STROKE TEST is recommended

- **Sensors (PT) have an internal diagnostic feature**
- **Logic Solver (PES) has an internal diagnostic feature**
- **Final Elements (SOV, Actuator, Valve) have not an internal diagnostic feature**

Diagnostic is a fundamental feature on Safety Instrumented Systems, because it can change the classification of a big portion of **Dangerous Failures** in **Dangerous Detected Failures**. This lasts are together with the **Safe Failures** in the SFF calculation and due to final elements have very low Safe Failure rate (sometimes zero) the application of a diagnostic test for the final element become mandatory to achieve the target SIL.

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Partial Stroke Test

Actual Types of PST approaches:

- **Slow moving with a valve positioner in parallel to the SOV's**
- **Slow moving with a PST device actuating a dedicated SOV in parallel to the trip SOV's**
- **Safety speed (fast) moving with a PST device actuating a dedicated SOV in parallel to the trip SOV's**
- **Safety speed (fast) moving using the trip SOV's (higher diagnostic)**

NOTE: It is important to consider that any device used for the PST function are not SIL certified for that function, so it is necessary the SIL certified Logic Solver to be the "monitor" of the valve correct stroking during the PST.

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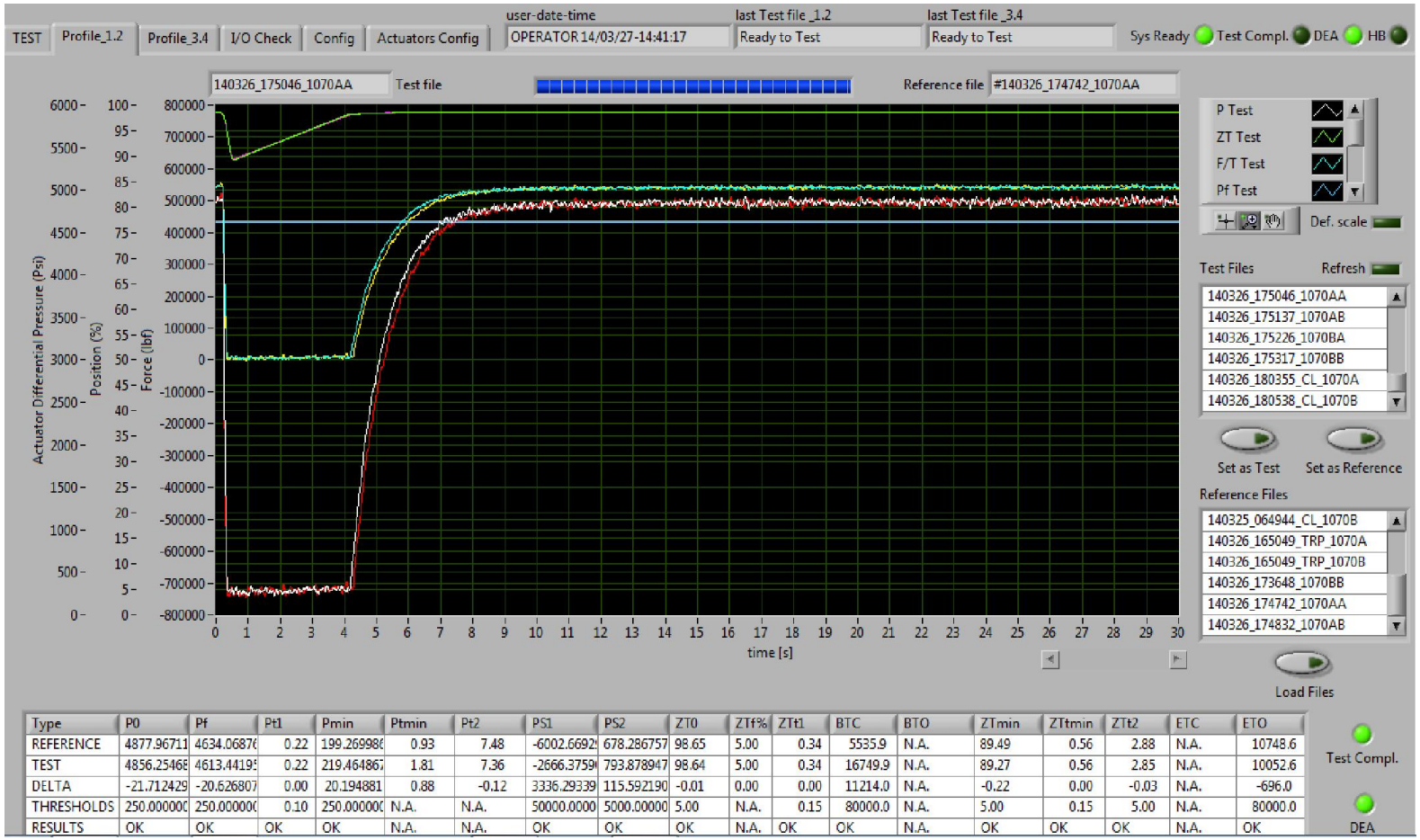
Diagnostic window



Type	P0	Pf	Pt1	Pmin	Ptmin	Pt2	PS1	PS2	ZT0	ZTf%	ZTt1	BTC	BTO	ZTmin	ZTtmin	ZTt2	ETC	ETO
REFERENCE	4877.96711	4634.06876	0.22	199.269986	0.93	7.48	-6002.6692	678.286757	98.65	5.00	0.34	5535.9	N.A.	89.49	0.56	2.88	N.A.	10748.6
TEST	4856.25468	4613.44195	0.22	219.464867	1.81	7.36	-2666.3759	793.878947	98.64	5.00	0.34	16749.9	N.A.	89.27	0.56	2.85	N.A.	10052.6
DELTA	-21.712429	-20.626807	0.00	20.194881	0.88	-0.12	3336.29339	115.592190	-0.01	0.00	0.00	11214.0	N.A.	-0.22	0.00	-0.03	N.A.	-696.0
THRESHOLDS	250.000000	250.000000	0.10	250.000000	N.A.	N.A.	50000.0000	5000.00000	5.00	N.A.	0.15	80000.0	N.A.	5.00	0.15	5.00	N.A.	80000.0
RESULTS	OK	OK	OK	OK	N.A.	N.A.	OK	OK	OK	N.A.	OK	OK	N.A.	OK	OK	OK	N.A.	OK

Valve Partial stroke position comparison

Actuator chamber pressure during partial stroke versus actuator chamber reference signature

Valve assembly force comparison

Tab data with automatic detection of the health of the final element assembly

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Complete HIPPS Solution

Engineering advantages of complete HIPPS solutions:

- Knowledge and experience of Safety System applications
- Approach as “integrator”, providing flexible solutions
- Ability to provide “pipe-to-pipe” solution and skid packages
- Execution of Integrated Factory Acceptance Test (IFAT)
- Complete HIPPS SIL Assessment Certificate by a 3rd part
- Single point of sourcing and accountability for the system

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HIPPS

HIPPS Design

Logic Solver

Logic Solver

Logic solver is made of three main subsystem:

- input channels
- CPU
- Output channels

Input channels

AI 1 1 2 3 4 5 6 7 8

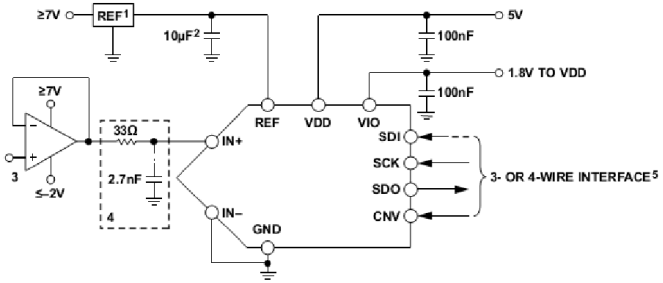
AI 2 1 2 3 4 5 6 7 8

AI 3 1 2 3 4 5 6 7 8

Analog input cards acquire 4-20ma signal from pressure and position transmitters and transform the signal into digital data.

Each module may have several input channels. Typically when voting is required (e.g. 2oo3 between transmitters), also redundant input cards for analog signals are used.

4-20ma



1010101010

1110101100

Converted data to CPU

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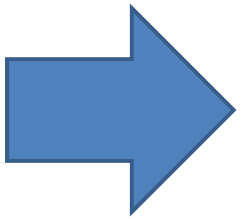
Logic Solver

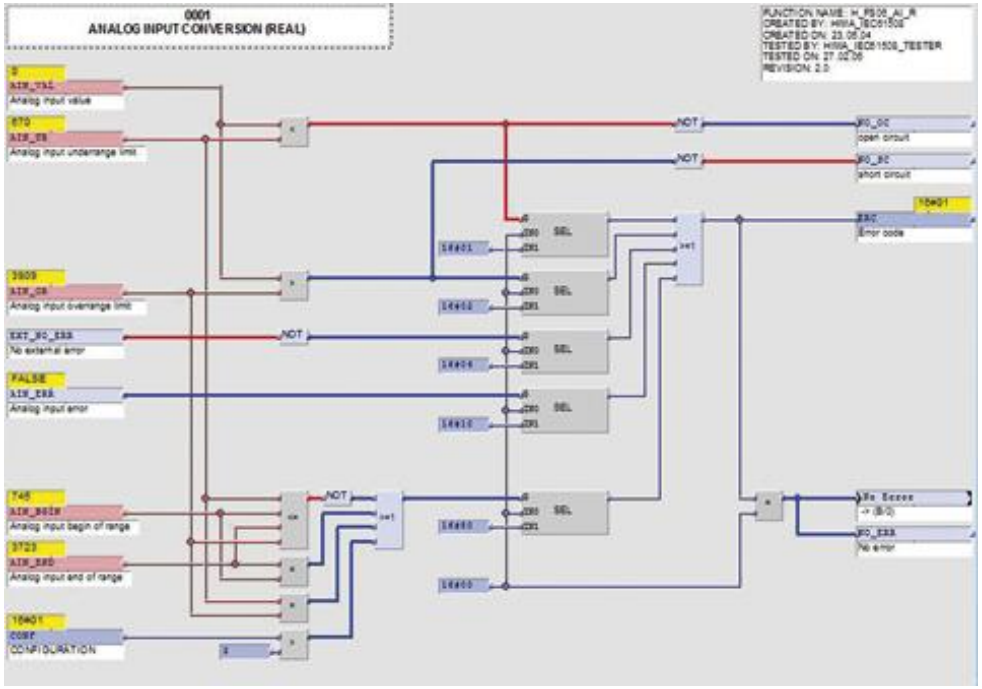
The CPU module performs the basic arithmetical, logical and input output operations of the system

1010101010

1110101100



Data is passed throught an algorithm running in the C.P.U.



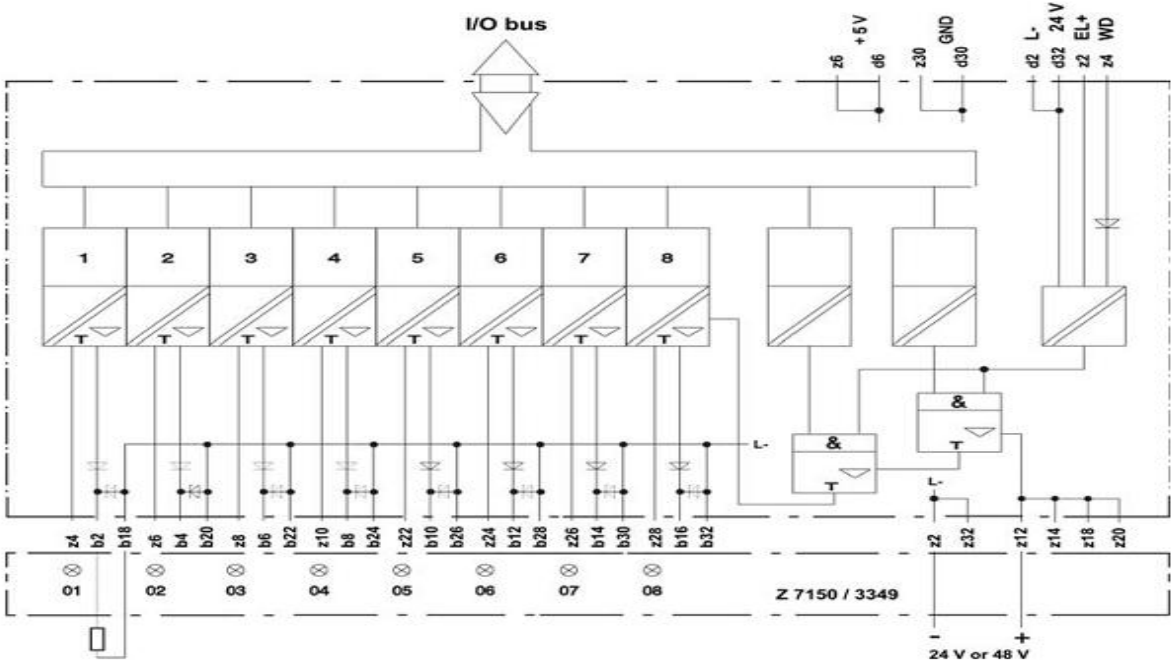
The CPU module performs the logical operations and command drive the output module.

Logic Solver

The output modules are connected to **solenoid valves**.

The output channels are safety related SIL 3 swiches (solid state or relays) with integrated circuitry for diagnostic and monitoring.

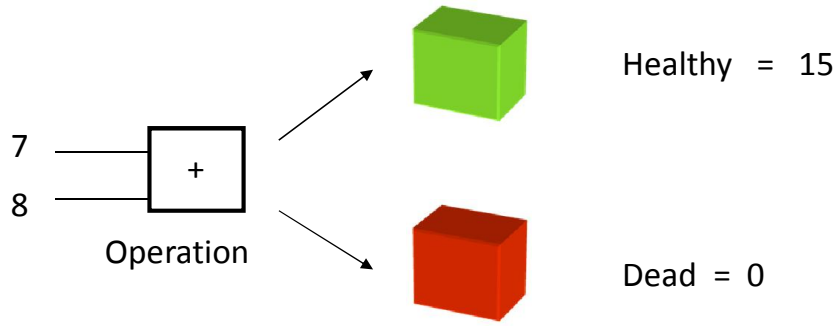
From C.P.U.



To Solenoid valves

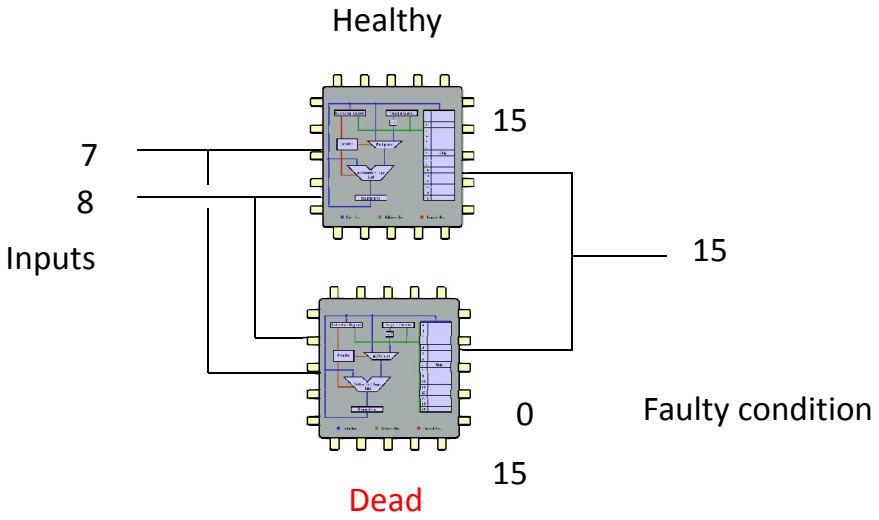
Logic Solver

inherently safe component



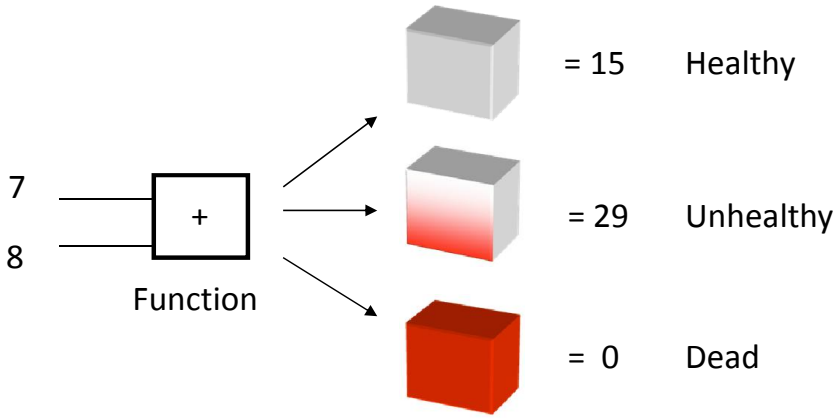
Only two states are possible

Effect of a fault

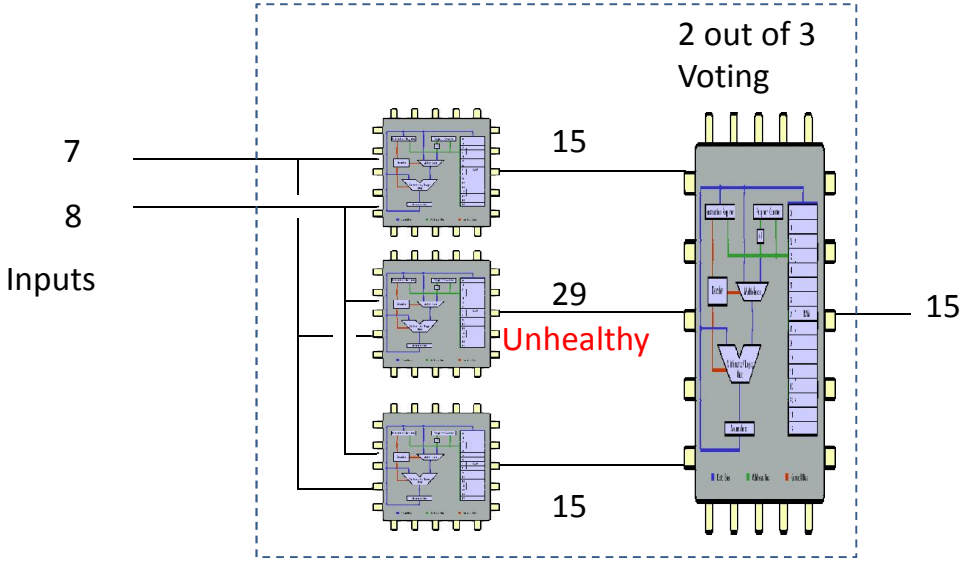


Logic Solver

Not-inherenthly safe component



An ordinary component can have three possible states



Triplication and majority voting

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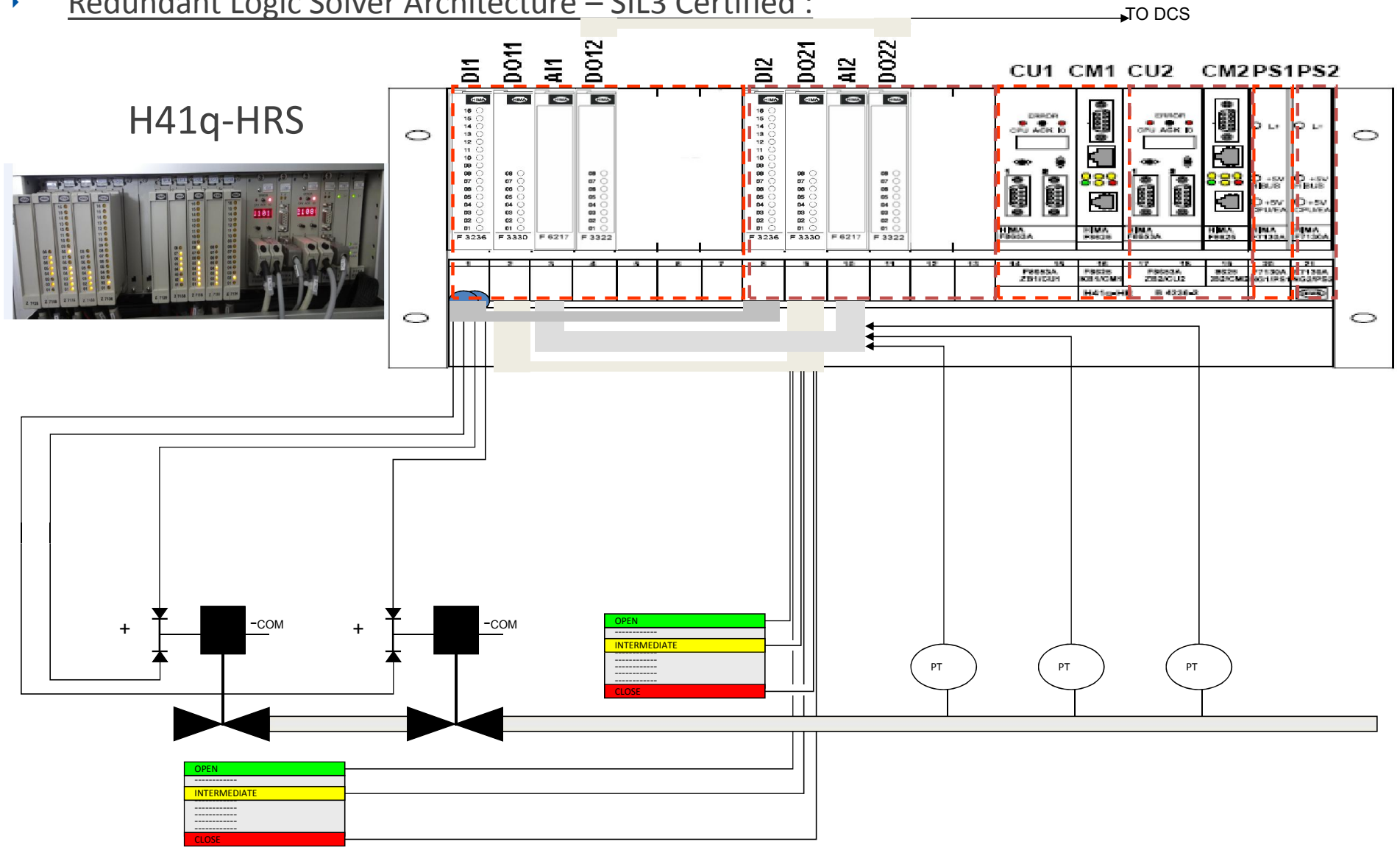
Logic Solver

- Redundant Logic Solver Architecture – SIL3 Certified :

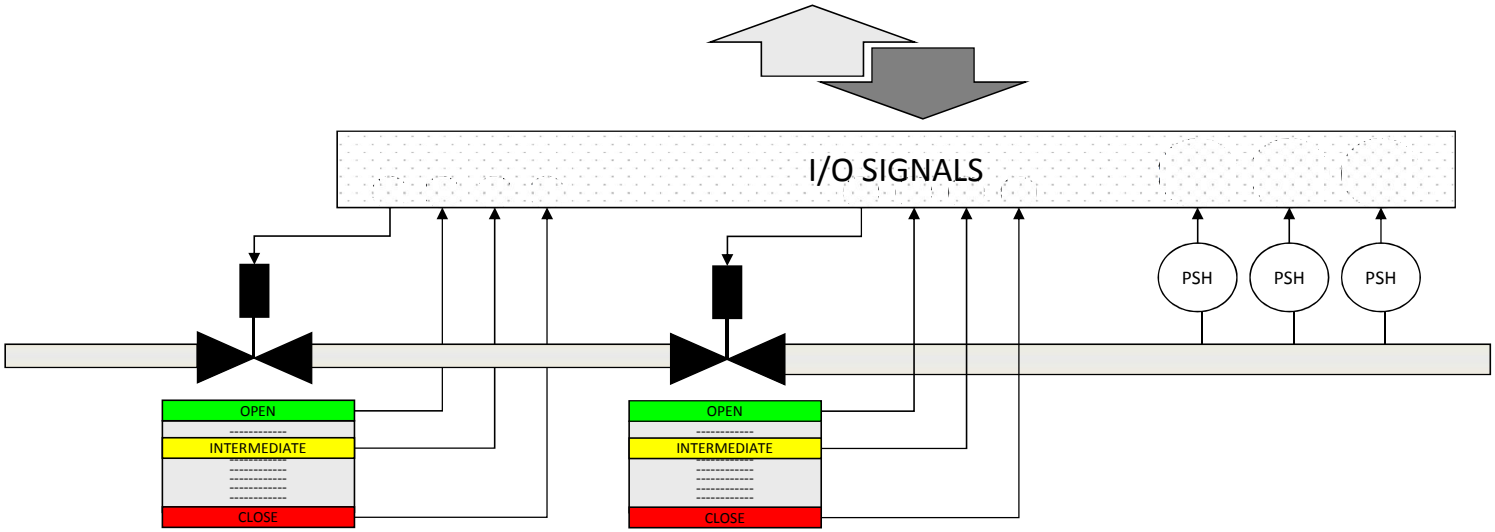


Logic Solver … solid state

HIMA Solid State

Hardwired Logic Solver
Planar 4

Cards and Communication Modules



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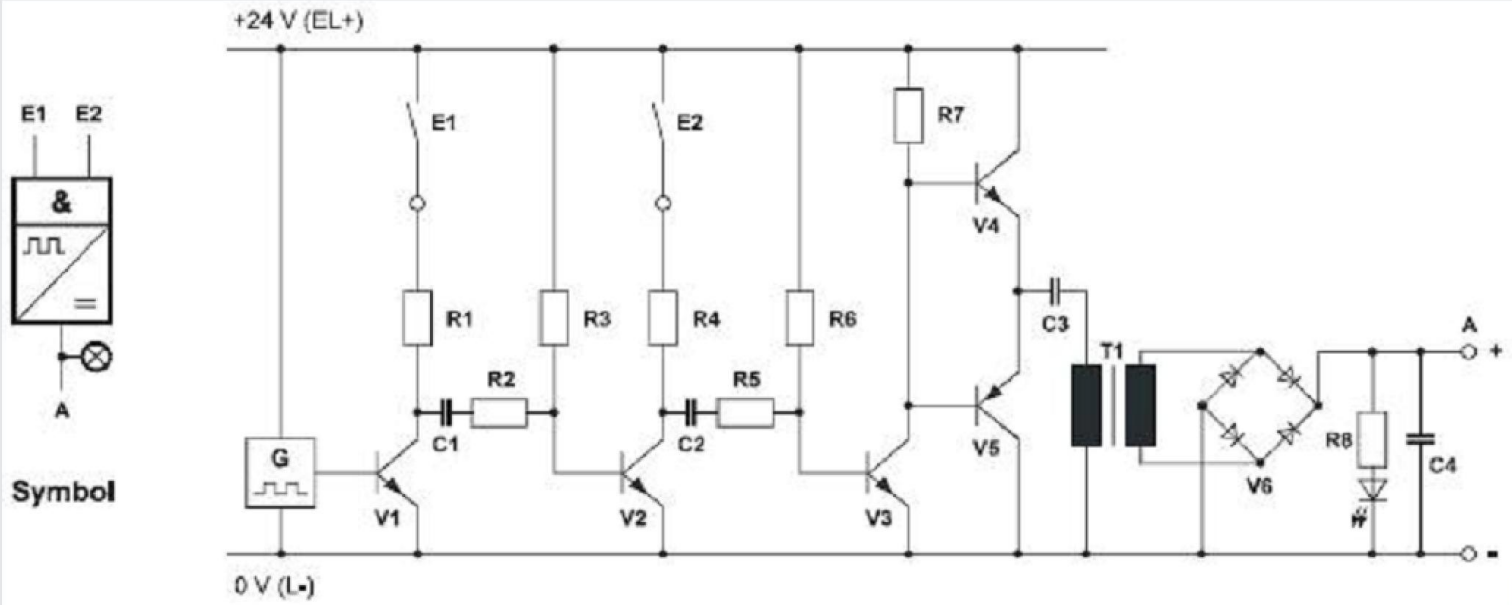
Logic Solver … solid state

Hima Planar 4 is a solid state logic solver SIL 4 capable.

Solid state system have great reliability parameters since it is based on “simple” discrete electronic elements like transistor, capacitors , resistors and oscillators.

Principal of AND-Gate (fail safe design)



A rectangle frequency of n KHz runs through the electronic components and is testing by this n-thousand times per second the correct functionality.
This generator is on each module to ensure safety and availability.

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Logic Solver … cabinet

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Logic Solver … HMI

The Logic Solver cabinet can be provided with a HMI PC.

The HMI (human machine interface) is installed in the control panel with a dedicated software for the visualization of process parameters, instruments readings, trend viewer and sequence of events recorders.

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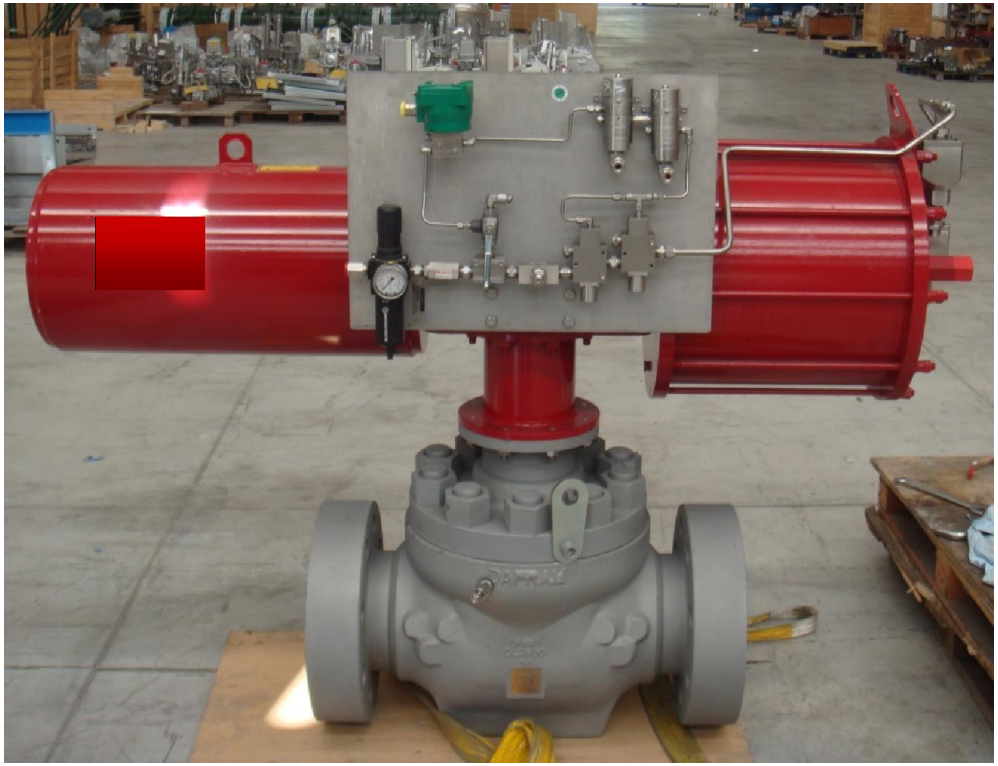
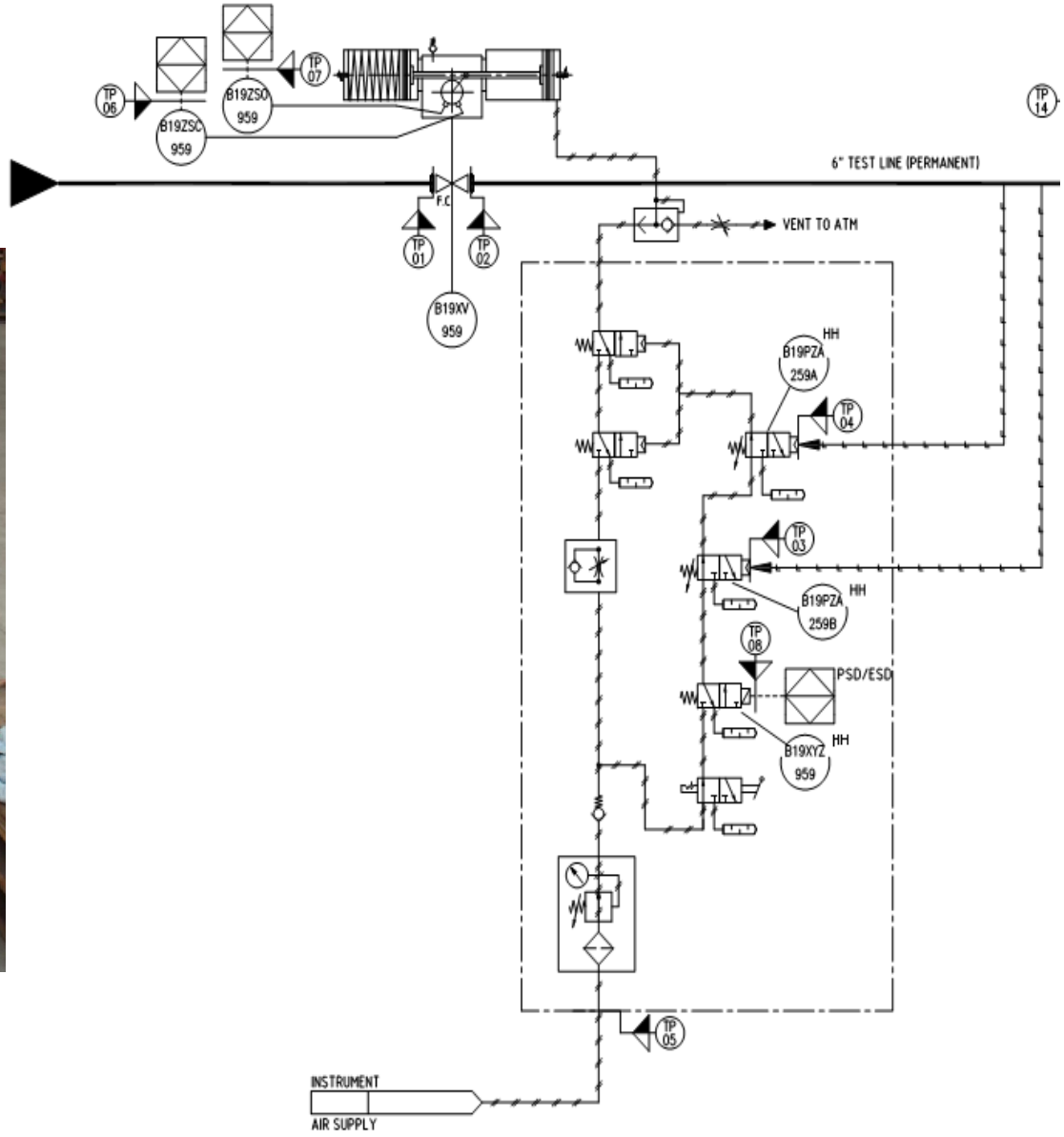
No Logic Solver? … self actuated solution

Pneumatic Self Actuated





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No Logic Solver? … self-contained solution

Hydraulic self-contained system

No external hydraulic supply unit is necessary

Opening of the valve is by manual pump

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CCI HIPPS Technology Belongs to IMI Critical Engineering (Previously 'IMI Severe Service')

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HIPPS – EI Wasit

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Engineering, construction, test and on-time delivery of:

Saudi Aramco – EI Wasit Offshore HIPPS

Project Scope Of Work

26 HIPS Systems Downstream Chokes API-6A 10k made of

- *52 Through Conduit GATE Valve design (2 valves in series per skid) with Inconel 625 Overlay (min. 3.0 mm machined) Full Bore Size: 210.9 mm ,API-6A PSL-3 with HP Gas Testing per API-6A PSL-4,Hydr- Actuator + Controls + LCP.*
- *26 Hydraulic Power Unit and accumulators rack for 2 Valves strokes (open-open)*
- *26 sets of Spool piece between the two HIPS valves with vent ball valve 1-13/16in API-6A 10k with 6BX flanges connected to 2.0 in 300# vent header with 2.0in 300# RF*
- *26 sets of modular skid frames made of HEA 240 ASTM A36 Killed Carbon Steel for HIPS System self supporting.*

13 HIPS Logic Solver Control Panel with CCI Stroke Test device

39 Pressure Tx's with Individual DBB isolating valve

39 Loop Powered indicators for Pressure Tx remote indication

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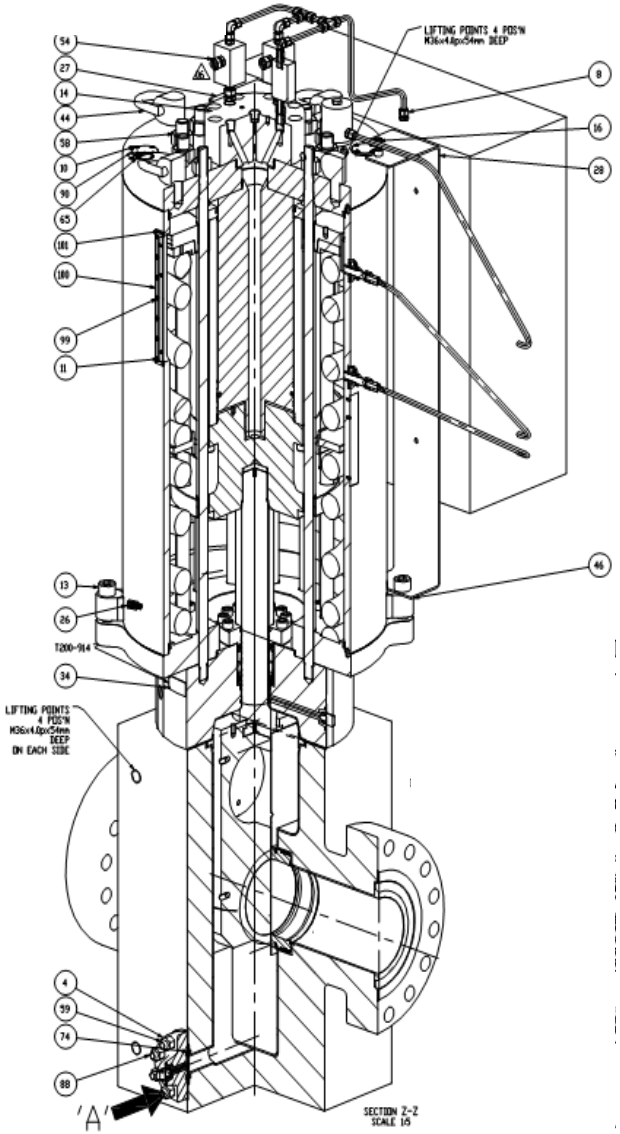
GATE VALVE MAIN CHARACTERISTICS

- 9.0” NB Through Conduit Slab Gate Valve
- Topside HIPPS Service
- 8.3” Actual Bore
- 606.73 Bar MAOP – 10000 PSI Rated
- Bolted Bonnet
- Rising Stem
- Slab Gate
- Metal-to-Metal Seats
- 9” API 10K Flanged End Connections
- BEL Hydraulic Spring Return Actuator 5000Psi – Fail Safe Closed



MATERIALS

- Body : ASTM A182 F22 (MODIFIED API 6A 60K) Fully Alloy 625 Clad
- Bonnet : ASTM A182 F22 (MODIFIED API 6A 60K) Fully Alloy 625 Clad
- Gate : Alloy 725 (Tungsten Carbide H.F.)
- Seat Rings : Alloy 725 (Tungsten Carbide H.F.)
- Seat Skirts : Alloy 625
- Stem : Alloy 725 (Tungsten Carbide H.F.)

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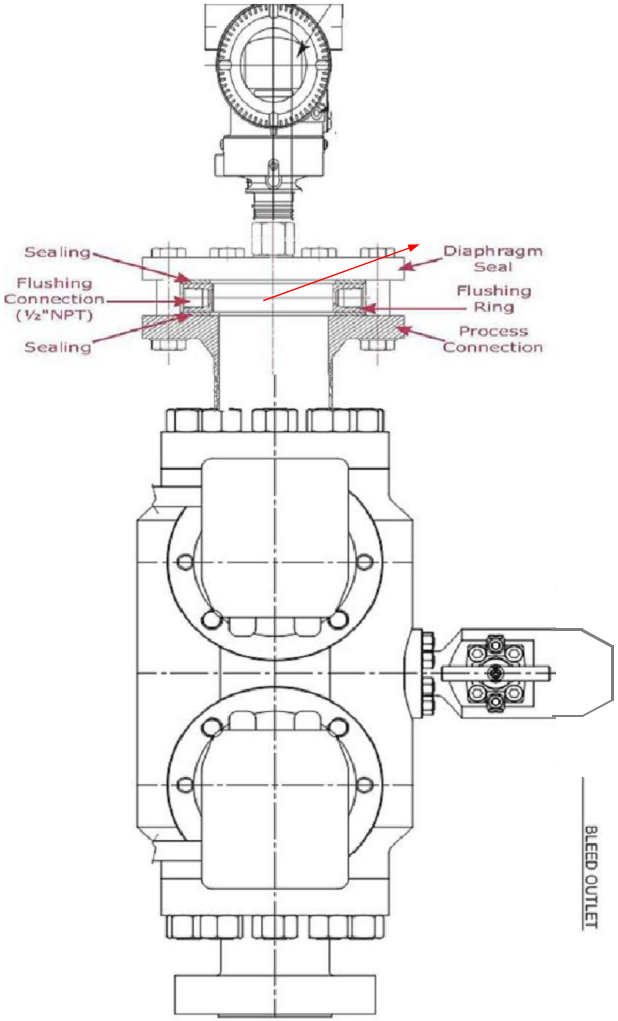
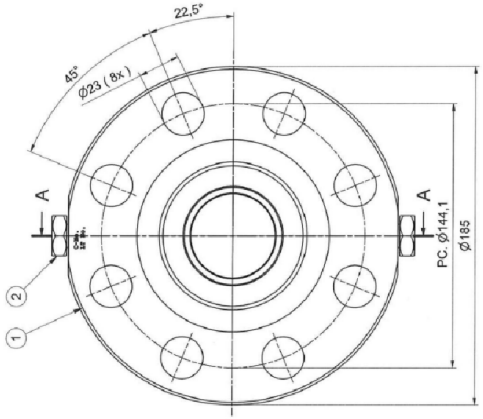
SIL Pressure Tx's with Individual DBB isolating valves





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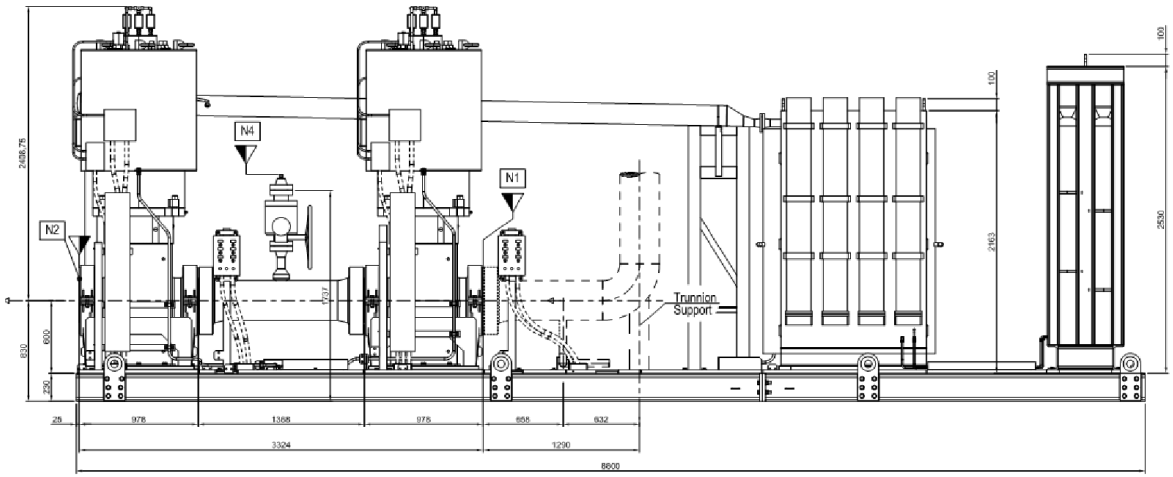
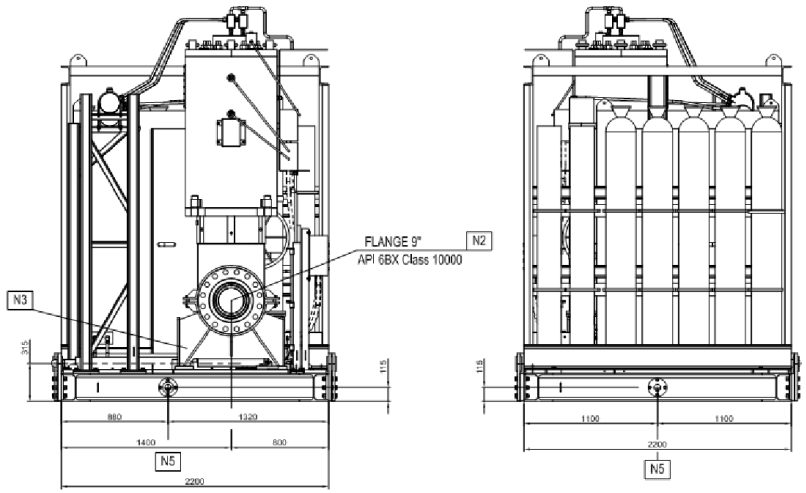
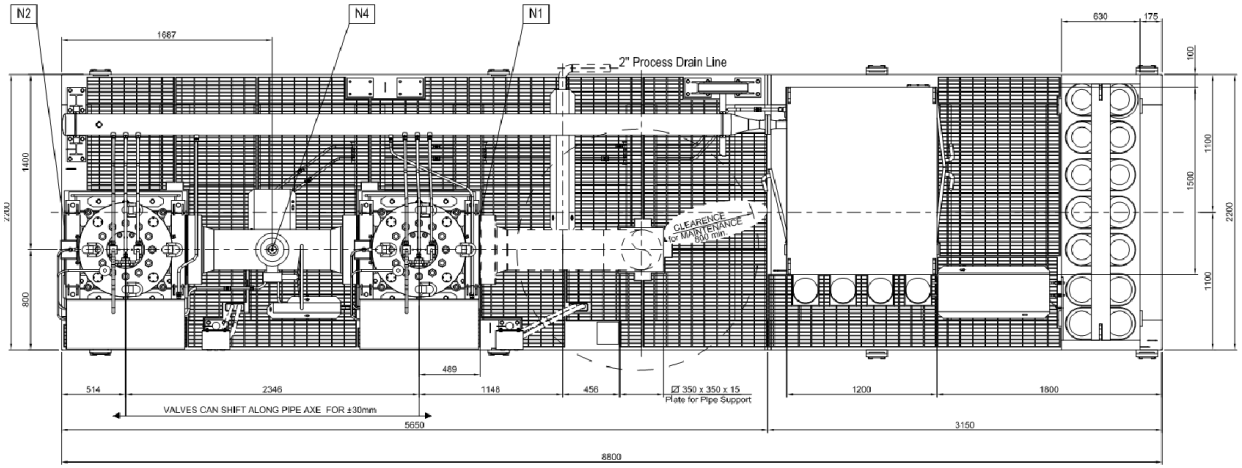
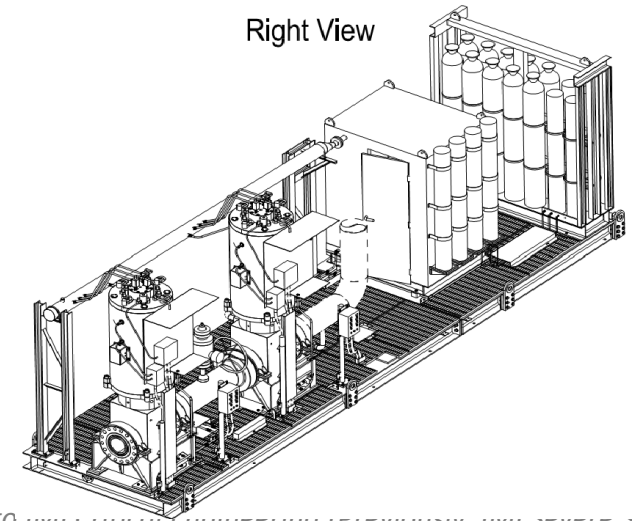
Skid Assembly







Right View



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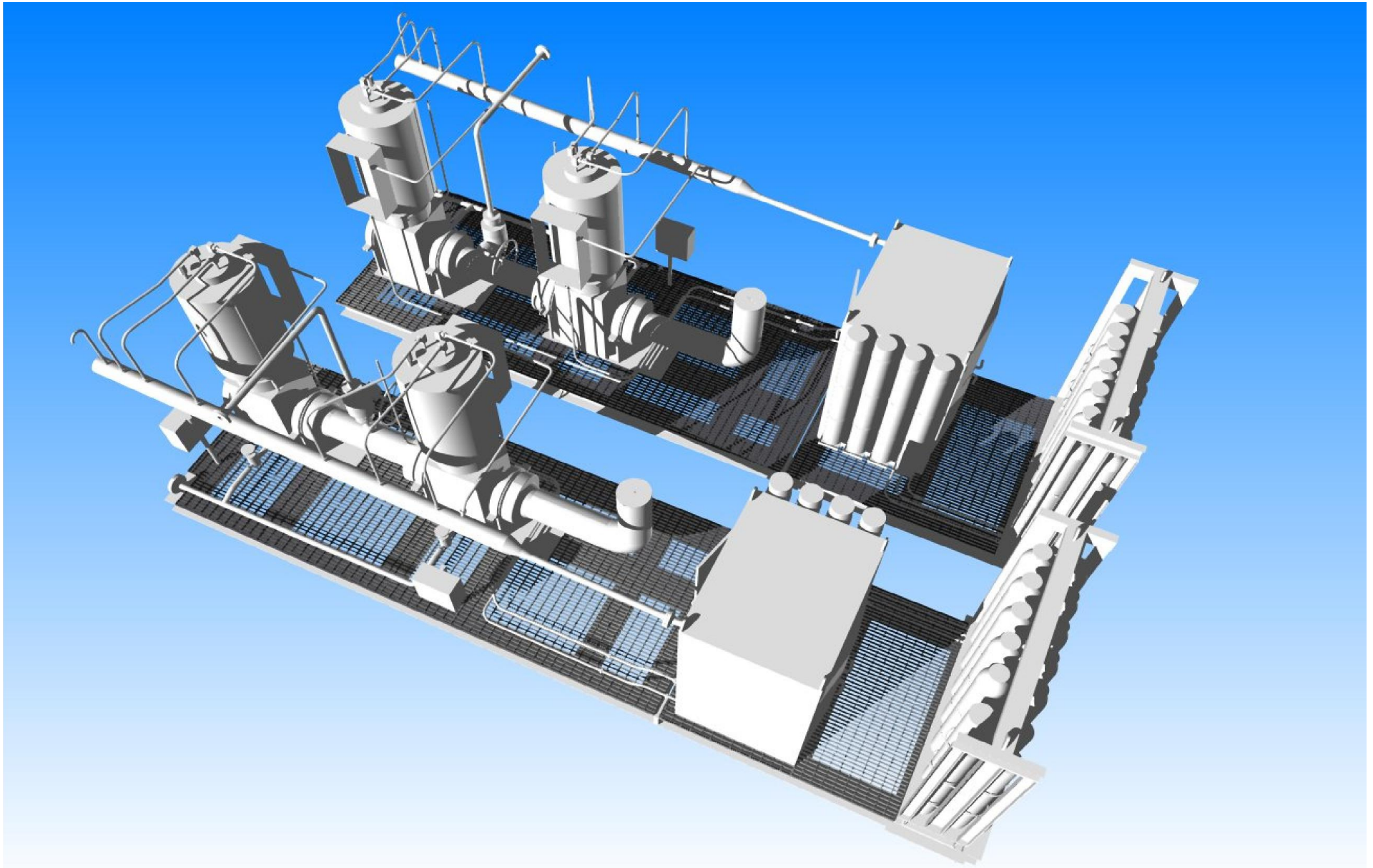
SKID assembly – 3D modelling



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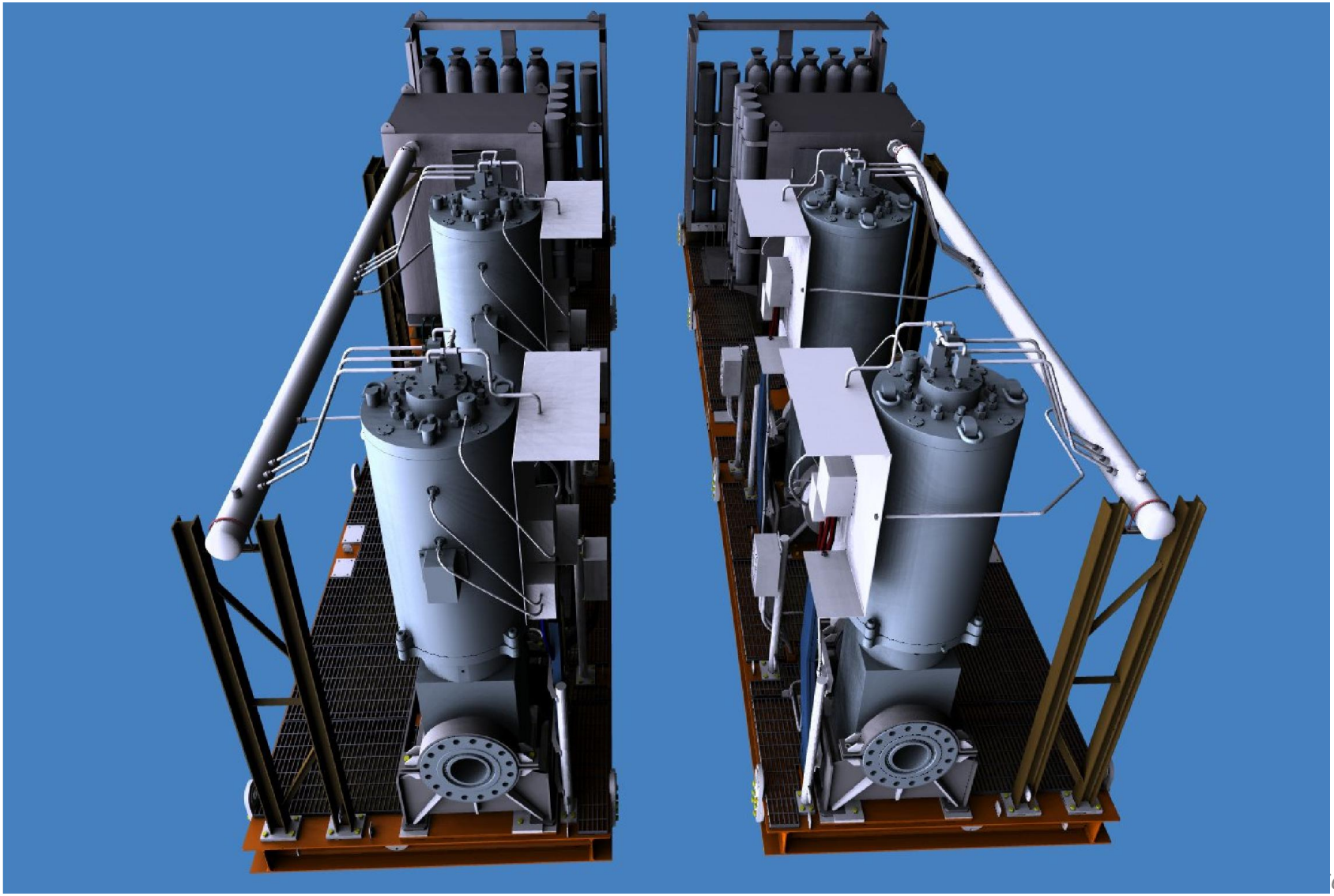
HIPPS – EI Wasit

Skid Assembly – 3D Modelling



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SKID assembly

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HIPPS – EI Wasit

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HIPPS – EI Wasit

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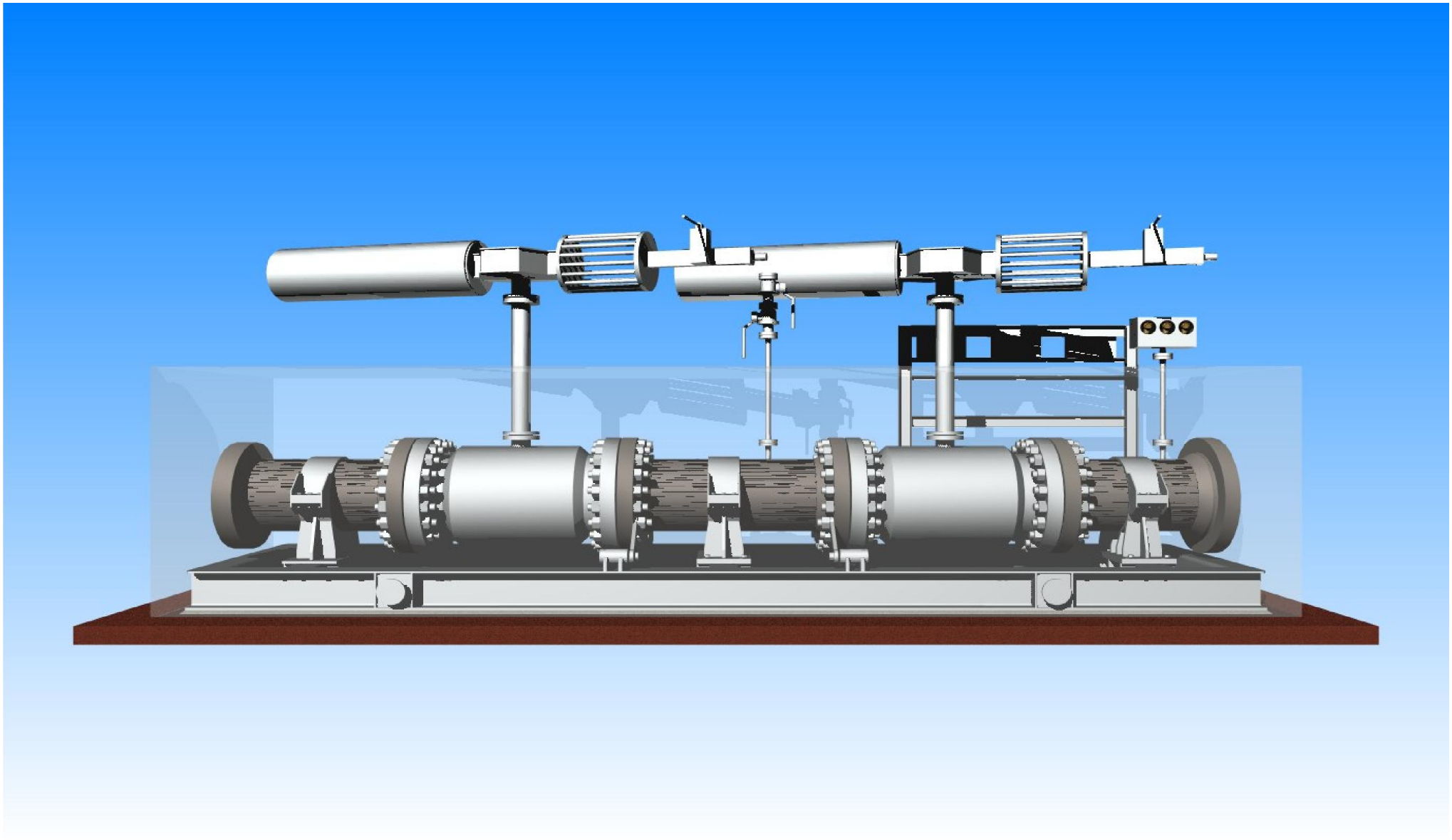
SKID assembly – 3D modeling



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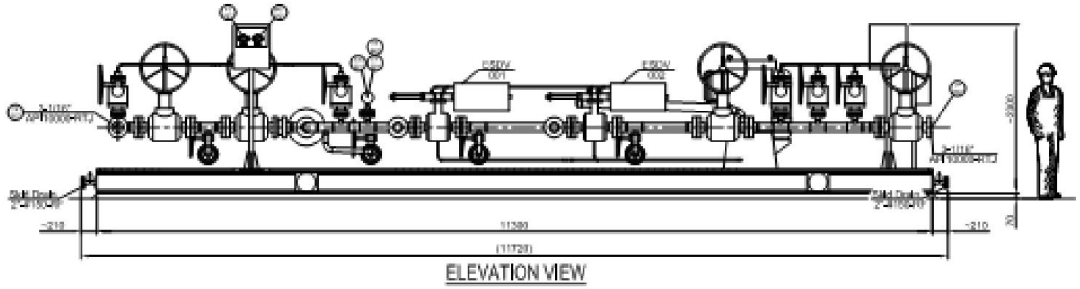

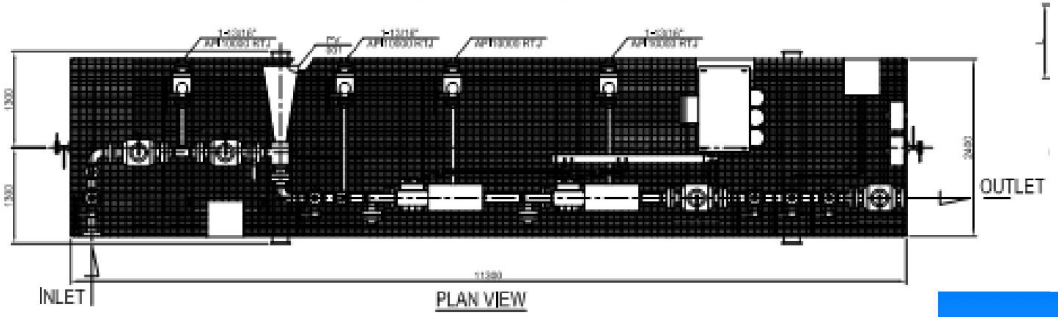

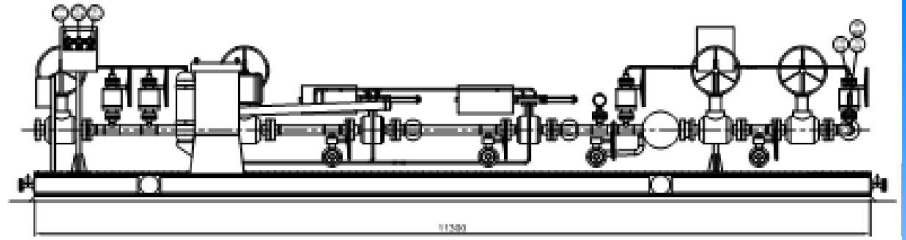

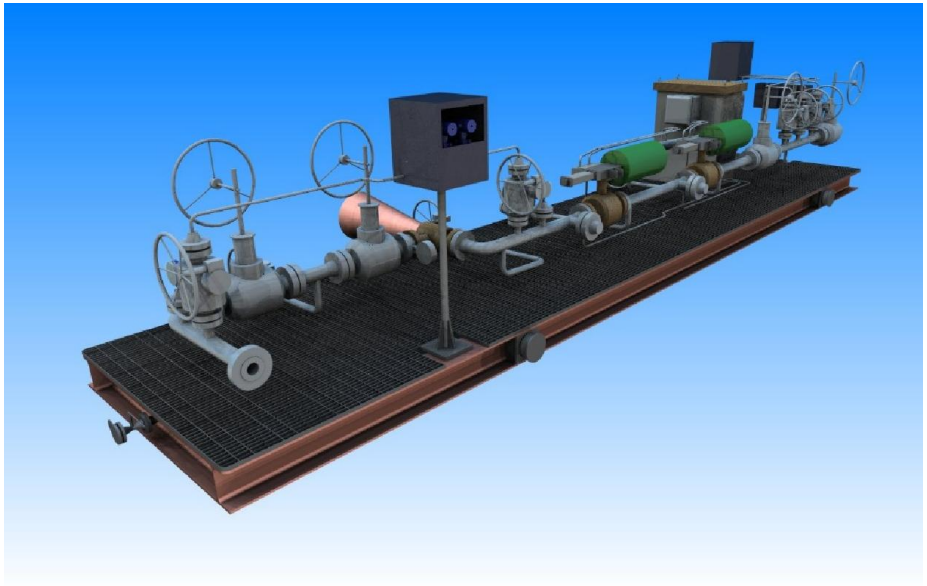

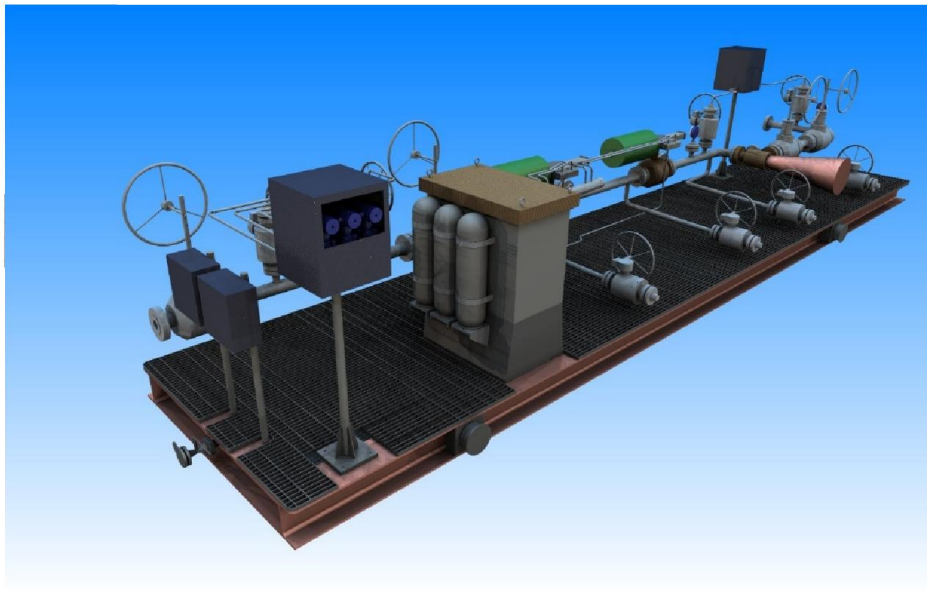

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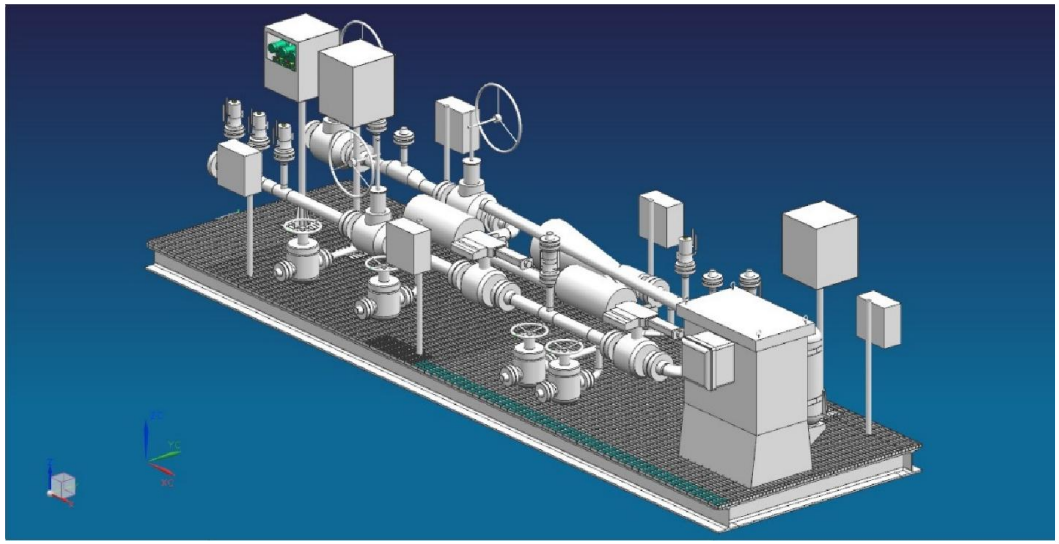
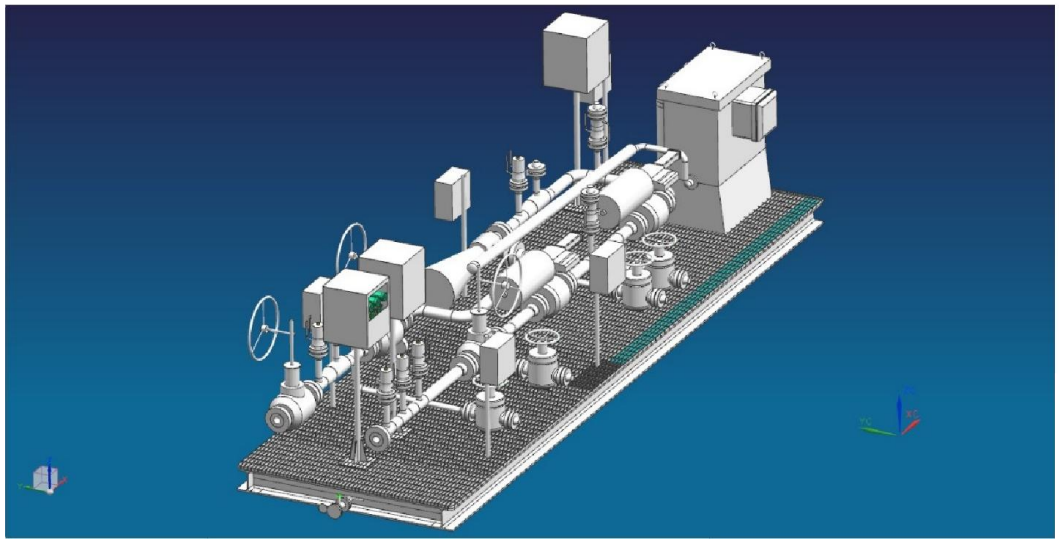
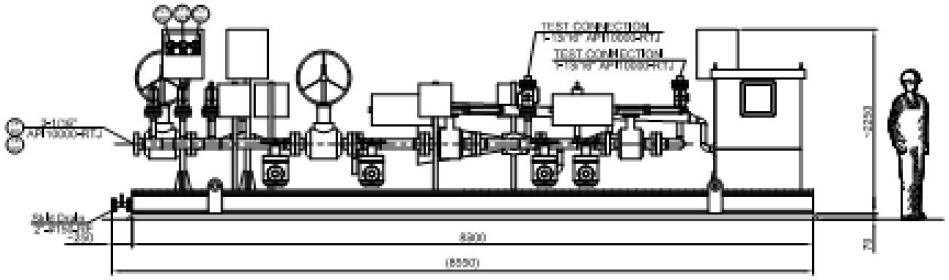
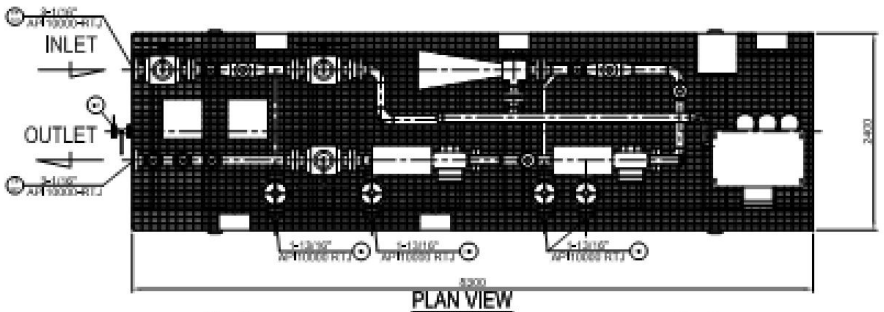


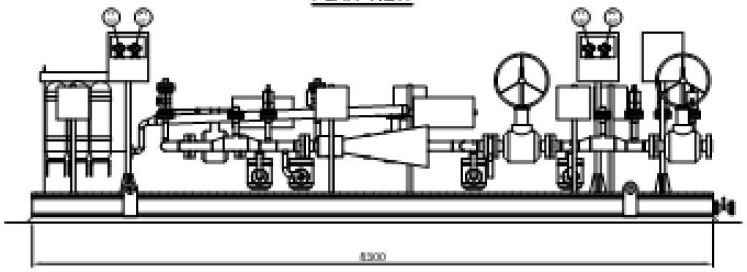




ELEVATION VIEW



PLAN VIEW



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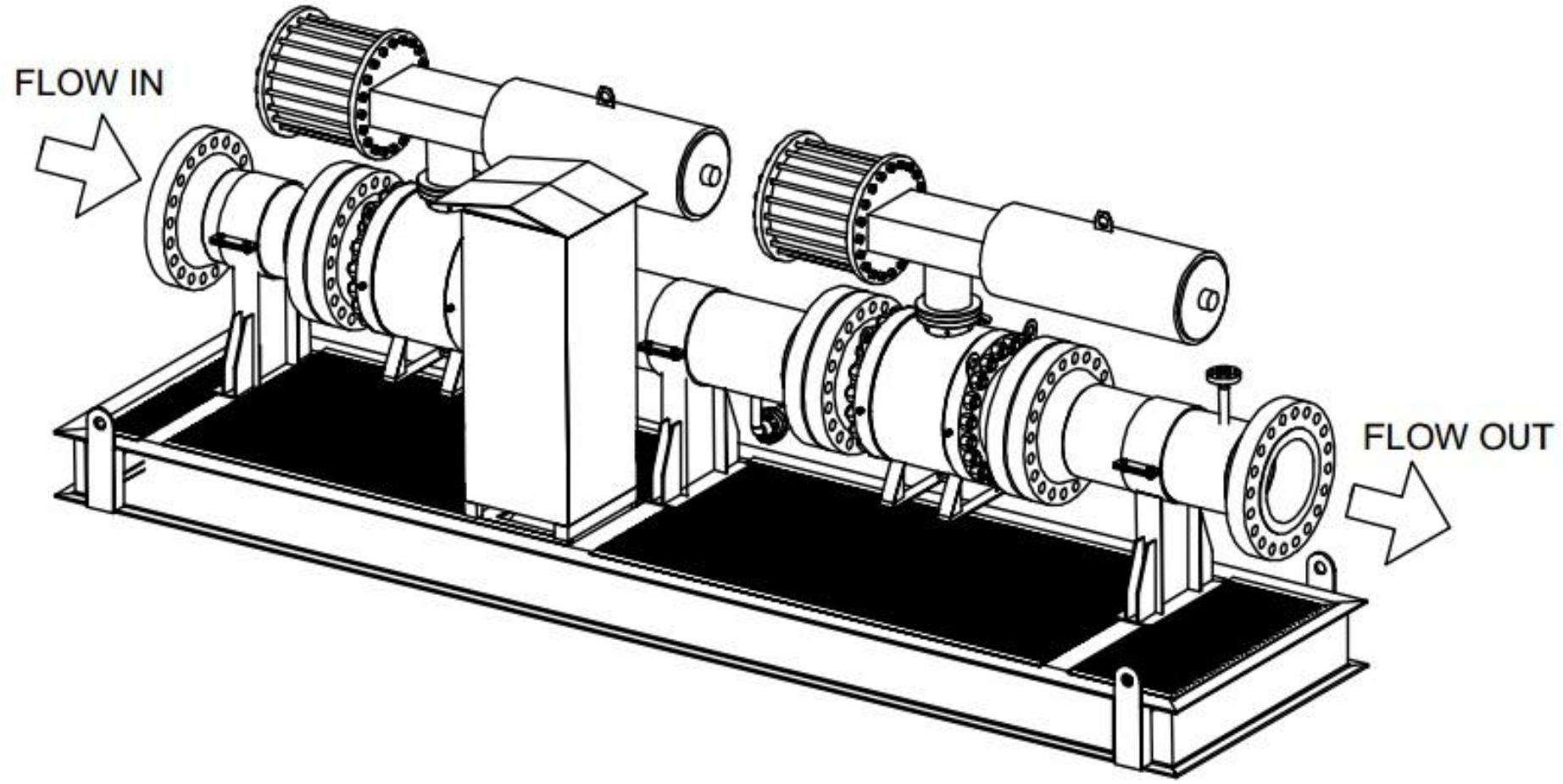

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Thank you

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