CMS FPIX Cooling Prototype

Phase One Estimate and Conceptual Design

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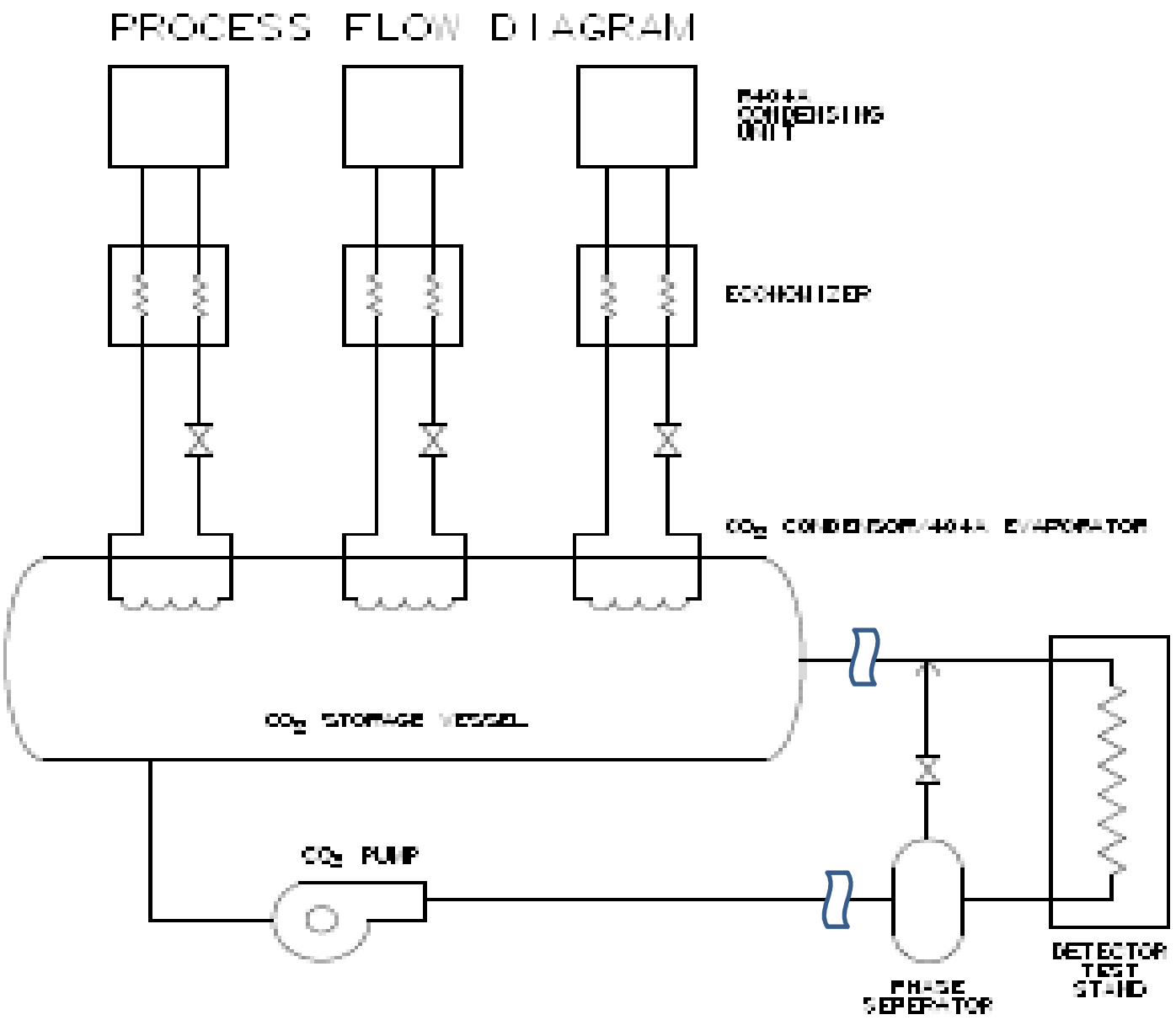
Specifications

- Based on 2008 specifications posted in docdb 2333
- System operates with panel temperature from -15 to +15C.
- Average temperature stability should be +/- 1C
  - Achievable with pressure control at phase separator
- Minimum operating temperature with no heat load, i.e. detector on or off, is -30C
  - Achievable with pressure control at storage vessel
- Maximum ambient temperature is 40C. Refrigerant shall be retained in at this temperature.
- Normal operation shall be automated so that operations is simply cooling system on/off control and setting the detector temperature.
- Total refrigerant leak rate should be less than 1e-2 atm-cc/sec.


PROCESS FLOW DIAGRAM
R404A CONDENSING UNIT
ECONOMIZER
CO_2 CONDENSOR/R404A EVAPORATOR
CO_2 STORAGE VESSEL
CO_2 PUMP
PHASE SEPERATOR
DETECTOR TEST STAND

Condensing Unit

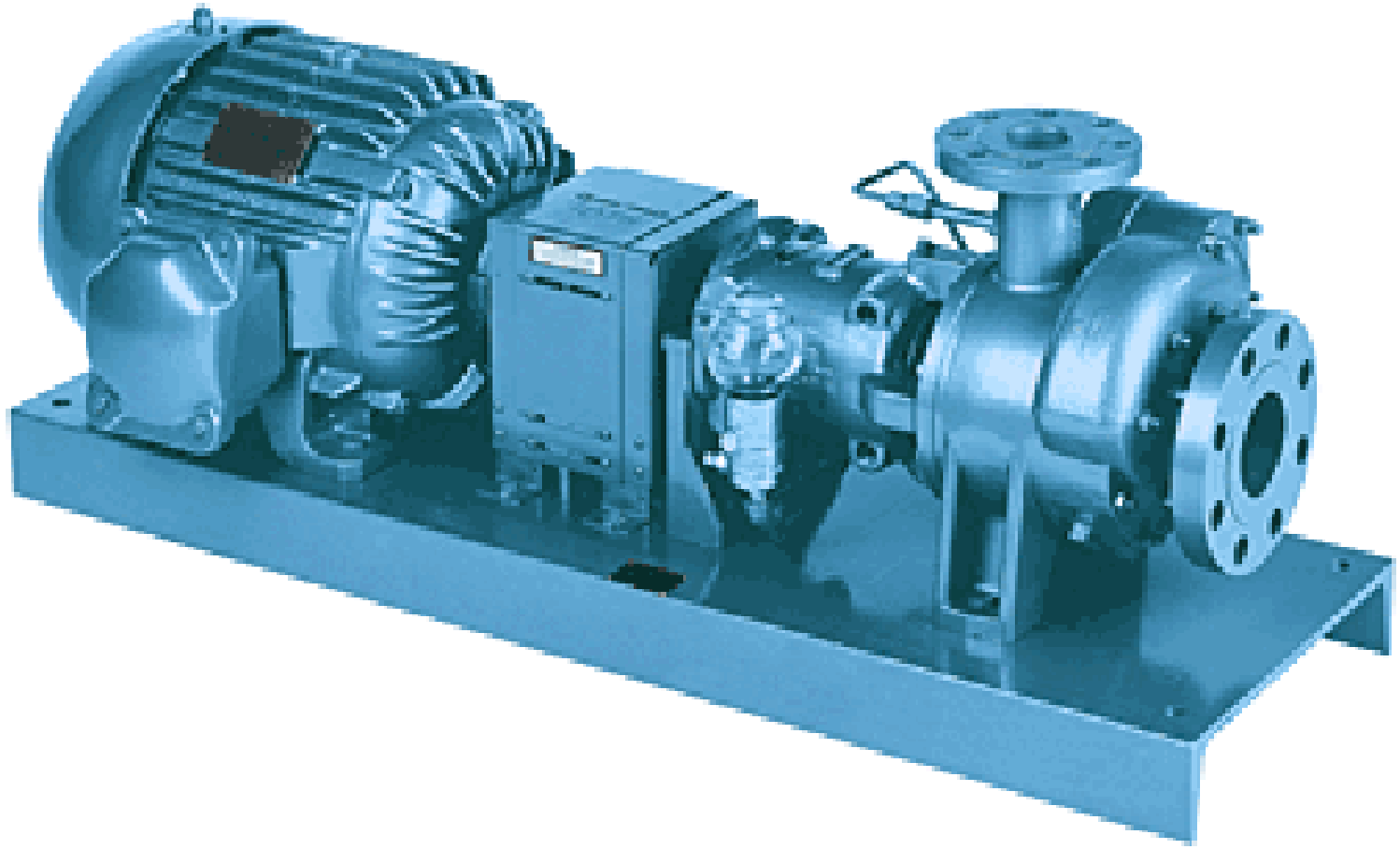
- Standard commercial units
- Scroll compressors
- R404A refrigerant
- Heatcraft part CZT025L6

Pumps

- Considered Three types of pumps
  - LEWA Diaphragm pump
    - Smaller version used in CERN-NIKKEF cooling system
    - High NPSH, 1 bar, or about ten meters
    - Twice the cost of the Roth turbine pump
    - 73 bar pressure rating
  - Roth turbine pump
    - Low NPSH
    - Magnetic drive
    - 69 bar pressure rating
    - Basis of estimate

LEWA LDD Diaphragm Pump

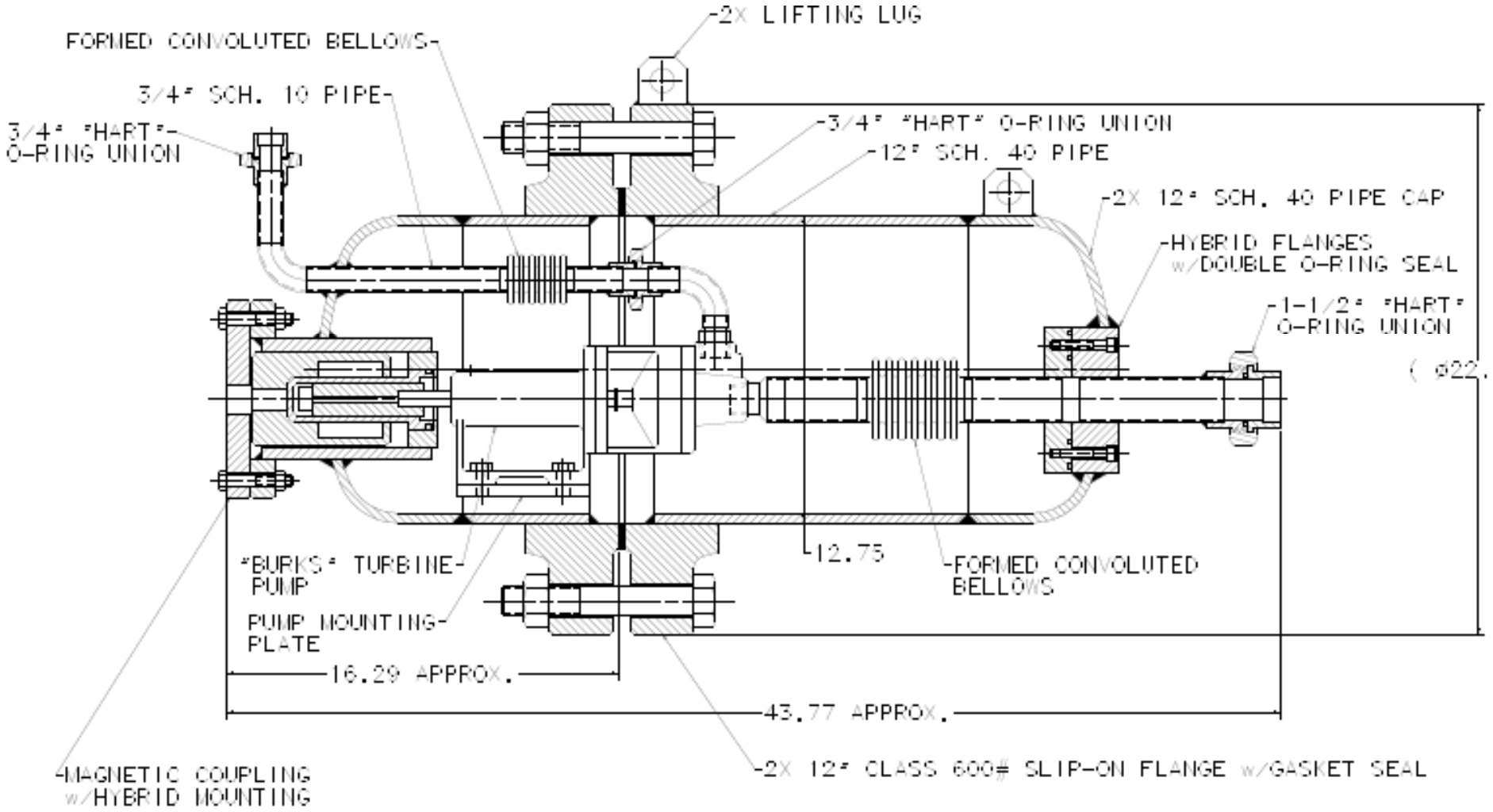
Roth MDW5133 Turbine Pump



Custom Canned Turbine Pump

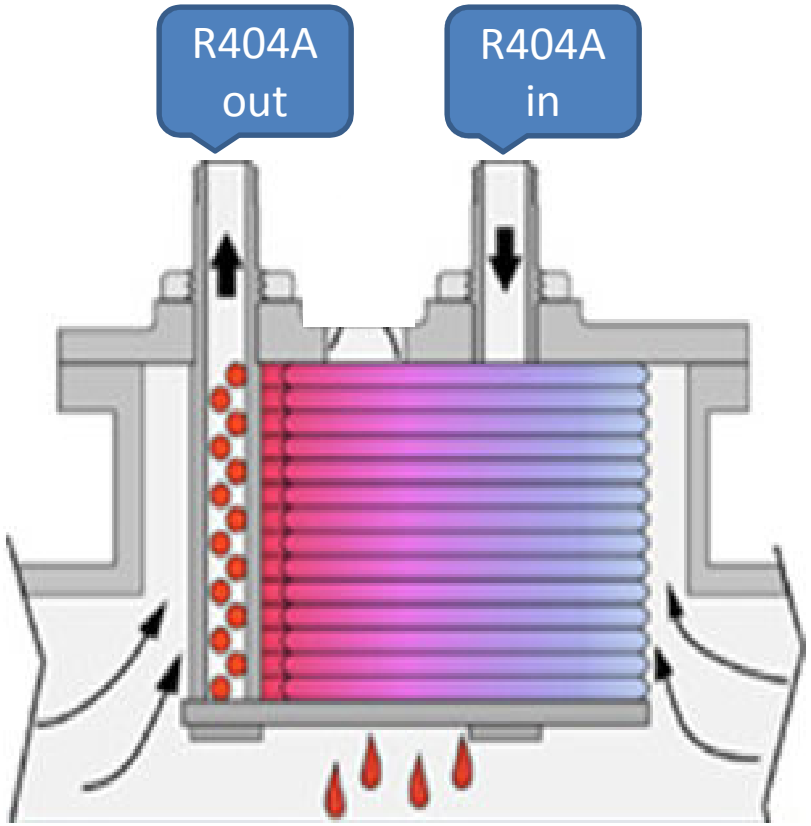
- Full pressure rating
- Pressure balanced with CO_2 gas
- Inexpensive pump, less than $1k
- Standard magnetic coupling
- Requires stainless pressure vessel, estimated at $15k
- Requires development

Canned Pump Conceptual Drawing



Heat Exchangers

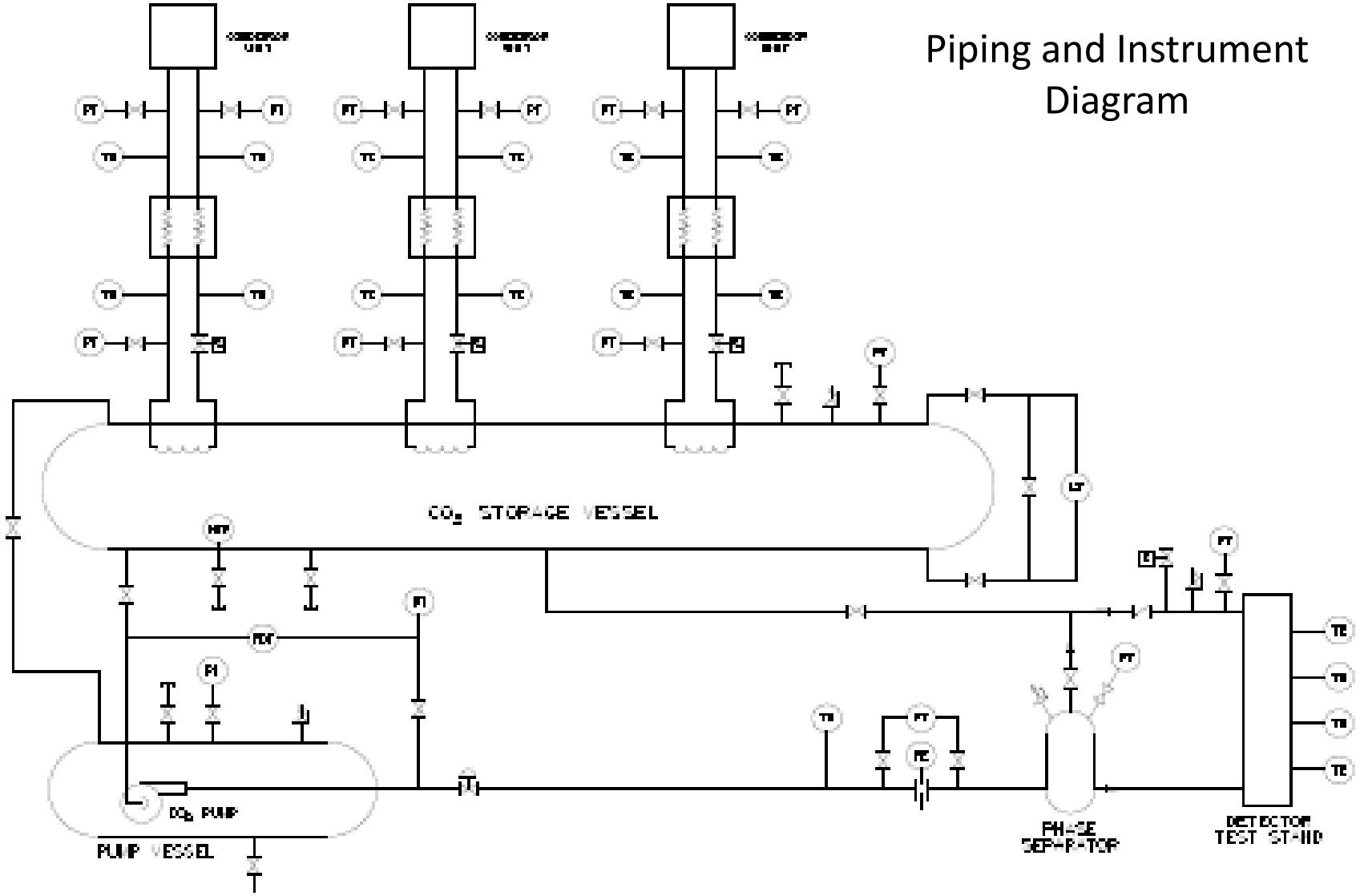
- CO_2 condenser/R404A evaporator
  - Mounts directly in storage vessel
  - Removable in case of problem



Storage Vessel

- Large enough to mount heat exchangers
- Large enough to contain total refrigerant charge
- Stainless steel material

Piping and Instrument Diagram



Scaling

- The Roth pump will be variable speed and could handle any detector size up to 15kW
- The capacity and number of condensing units could change, possibly required different sized storage vessel.
- The design effort does not change with scale
- M&S would decrease with size, but not a lot
- Recommend that size be based on need.

Possible Combination with BPIX

- Assume shared inlet temperature
- Mis-matched pressure drop
  - Add flow restriction to FPIX
  - Increase BPIX tube size
  - Separate phase separators
- No problem for turbine pump
- Larger or more condensing units
- Recommend BPIX decrease exit quality to 1.2
  - 2.0 mm ID tube same ΔP as FPIX 1.4mm ID tube

Backup slides

References

- Specifications
  - https://docdb.fnal.gov/CMS/DocDB/0023/002333/004/CMS%20Upgrade%20Cooling%20Specifications11_21_08.pdf
- Condensing Unit
  - http://www.johnstonesupply.com/corp/OnlineCatalog/ProductDetails/tabid/1780/Default.aspx?Product_Code=B94-313
- Roth Pump
  - http://www.rothpump.com/Media/chemical.pdf

Tope Estimate of 5/28/2009

FNAL CMS CO_2 cooling R&D setup cost estimate Item or Task	M&S	Engineer or Designer Man Weeks	Technician Man Weeks
ASME coded CO_2 storage vessel	$20	1	---
ASME coded relief valve & rupture disk	$3	0.5	---
FESHM required pressure vessel engineering note	---	2	---
Liquid CO_2 pump	$25	0.5	---
Chiller	$50	0.5	---
Vacuum pump	$6	---	---
AC power distribution	$5	0.2	---
CO_2 filters	$4	1	---
Valves	$15	0.5	---
Tubing, fittings, and system fabrication	$20	2	8
Heat exchanger	$5	1	---
FESHM required piping engineering note	---	2	---
PLC controller, programming, wiring	$10	3	4
PC, HMI software, and programming	$4	2	---
Component lists and piping schematic	---	0.5	---
Operating procedures	---	0.5	---
Instrumentation	$15	1	---
Insulation	$3	2	4
CO_2	$2	---	1
Operations support	---	2	4
Totals without contingency	$187	22.2	21

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