How to Collect, Form and Ship 4.5 Million Tonnes of Sulfur per Year

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Continuing Growth of Qatar’s Gas Production & Processing

Multiple sour gas processing facilities will ultimately produce up to 12,000 tonnes/day of by-product sulfur

This requires proper collection, processing and shiploading of sulfur to ensure uninterrupted RLC plants operation while meeting strict environmental regulations

Therefore the CSF objectives are to:

- Establish a robust, safe and environmentally friendly facility
- Operate continuously all year
- Ensure continuous LNG, GTL, natural gas and NGL production from RLC
Common Sulfur Berth/Jetty Area
CSF Scope of Facilities

FOR MOLTEN SULFUR:

- Multiple producers @ up to 12,000 TPD sulfur
- More than 30 km of electrically-heated molten sulfur collection pipelines
- Molten sulfur storage & conditioning system
- Emergency sulfur blocking system

FOR SOLID SULFUR:

- Sulfur forming system
- Sulfur conveying & storage
- Sulfur shiploading system
Redundancy and Reliability Provisions for Sulfur Facilities

- Two 100% capacity molten sulfur collection pipelines
- Two 100% capacity electric heating tubes per pipeline
- 7 SEEHT circuits along each pipeline
- Two molten sulfur storage tanks @ Berth Area & with each Producer (provides combined 7 days storage)
- Two spare granulator feed pumps
- Two spare granulators
- Two 100% product storage conveyors
- Two 100% stacker / reclaimers
- Solid product storage building (Up to 21 days capacity)
- Two 100% capacity shiploaders
- Two 100% Steam Boilers
## Major Project Equipment Suppliers

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CSF Simplified Process Flow Diagram

2 Molten Sulfur Storage Tanks
- 11,700 Tonnes each
- Average sulfur temp. = 125-140 deg. C
- Total 2-day storage capacity

2 Molten Sulfur Pipelines for maximum redundancy

13 Enersul GMx1 Granulators
- 11 operating, 1 down, 1 standby in normal operations
- 50 t/h capacity each

Emergency Sulfur Blocking
- 6 Blocks, 1 Year Storage Capacity

Molten Sulfur Gathering and Granulation

Granulator Feed Pumps and Heat Exchangers

Truck Unloading Station
- 5 trucks/hour unloading capacity @ 18 tonnes/truck

Temporary Truck Unloading Station
- 5 trucks/hour unloading capacity @ 18 tonnes/truck

To be removed during staged construction and commissioning of CSF

Existing Silo

Existing Linear Shiploader

Quadrant Shiploaders
- 2 Rated @ 3,700 t/h each

Solid Sulfur Storage Building
- (115m wide x 153m long x 42m tall)
- 2 Semi-Portal Stackers/Reclaimers
- 1,500 t/h reclaim rate per reclaimer

Transport Vessel
- 40,000 tonnes net max

(Berth Draft Limit)

Individual RLC Sulfur Producers

Solid Sulfur Handling

*Recommended by CSF Team
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RLC Sulfur Producers

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Total 5-day storage capacity per producer*

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URS
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URS
Brimstone Sulfur Symposium 2010
POWER INFRASTRUCTURE FEDERAL INDUSTRIAL & COMMERCIAL
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*Recommended by CSF Team*
Overview of the Common Sulfur Facilities Located in the Berth Area
Lesson Learned: Steam System Design

In refineries and gas plants

- 10’s to 100’s of thousands of lb/hr steam systems
- In gas plant, most of the steam may be produced in the SRU/TGCU
- Heat Loss in steam jacketed and traced equipment and piping is estimated and included in the steam balance, say 5% of Total
- Standard steam supply and condensate return details are used based on past experience
Lesson Learned: Steam System Design

- Initial Single-Level Steam System designed for maximum 4 barg operating pressure (say 60 psig, 425° K)
  OK - 305° F, ~150 °C

- Provides good temperature for molten sulfur pipe and equipment jacketing, molten sulfur storage tank heating, for granulation fines remelt, and for remelt of frozen components if needed.

- No other large steam producers or users!

- Boiler Capacity 6700 lb/hr

- Engineers/Designers not familiar with this situation!
Lesson Learned: CSF Steam Requirements and Situation

- No SRU - But two storage tanks and plenty of molten sulfur piping and equipment

- Use of all electric heating and tracing deemed not practical

- Electric-Heated Steam Boilers chosen

- Jacketed piping required by project specifications and standards (vs. Controtrace®)
Lesson Learned: Boiler Sizing

◆ Estimated Jacketed Piping Lengths and calculated worst case ambient heat loss
◆ Determined Equipment Jacketing, Tank Heating Coils and Tracing needs
◆ Not all vendor information finalized when Boilers were to be ordered
◆ What design margin should be specified?
◆ What is missing?
Lesson Learned: Jacketed Sulfur Piping Heat Loss

◆ Measure “Actual” Jacketed Piping Lengths and calculate worst case ambient heat loss

◆ Designers Comments:
  
  ◆ Steam Jacketing only needed if there is no flow.
  
  ◆ Once sulfur is flowing it will keep things hot.
  
  ◆ The steam is the only thing exposed to the ambient temperature and it takes care of the heat loss.

◆ What was missed?
Lesson Learned: Jacketed Sulfur Piping is really a Double Pipe Heat Exchanger

◆ Re-calculated total “heat transfer”
  • To ambient
  • To flowing sulfur
  • Including heat loss from all steam and condensate equipment and piping!!!

◆ Problem Solved?? NO!
Lesson Learned: Jacketed Sulfur Piping is really a Double Pipe Heat Exchanger

◆ Remember, Granulators require a specific feed temperature for premium quality granule production

◆ The double-pipe heat exchanger (jacketed piping) from the pumps/coolers to the granulators brought the sulfur back to steam temperature - say 305F vs 255F to 275F required.

◆ This delta on 12,000 TPD far exceeded Boiler Capacity

◆ Provided a 4 barg steam letdown into a lower pressure header for granulator feed piping to operate at 1.4 to 2.2 barg (257F-275F, 125-135C, 398-403K) to match specified granulator feed temperature range.
Pipeline SEEHT System

- SEEHT selected for technical and economic merit
- System divided into 2 multiple control circuits
- Fiber optic temperature monitoring provides profile of the entire pipeline heating
- Failed cables will be replaced without disturbing the system
SEEHT Pipeline
Lesson Learned: SEEHT Pipeline

Temperature control at turndown

- The pipeline operated at well below minimum design flow for the first several months of operation

- Temperature control problems were experienced:
  - Control thermocouples generally just downstream of an input from a operating SRU tie-in
  - At “zero” sulfur flow – FINE
  - At greater than minimum design flow - FINE
  - At Zero to Minimum – with hot sulfur being received from a producer
    - Temperature controller shuts off power and at very low flow
    - Sulfur freezes before it hits the next SEEHT control loop (up to 5 km)

- Second downstream TIC needed to maintain hot pipeline
Enersul GXm-1 Sulfur Granulator

Enersul GXm-1 Granulators

50 TPH capacity per Granulator

Currently used by Qatargas

13 Granulators at full development
Enersul GX-1 Granulators
Enersul GXm-1 Granulators
Sulfur Storage Building
Sulfur Storage Building
Sulfur Storage Building
TKRI Stacker/Reclaimer Representation

TKRI Stacker/Reclaimers

- 3 modes of operation:
  - Stack / Bypass / Reclaim
  - Stack & Bypass: 700 TPH
  - Reclaim: 1,500 TPH
Stacker/Reclaimer
Sandvik Quadrant Shiploader

Quadrant Shiploaders (2)

- Designed working envelope to load 60,000 dwt vessels
- Capacity 3,700 TPH
Sandvik Quadrant Shiploader
Foundations for Second Ship Loader
Sulfur Blocking Area
Sulfur Blocking Area
Aerial View of Berth Construction
Aerial View of Berth Construction

There is nothing “common” about the Common Sulfur Facility!
...and it all comes down to this: