

DEP SPECIFICATION

**REFRACTORY LININGS FOR SULPHUR RECOVERY UNITS
(CLAUS AND SCOT)**

DEP 64.24.32.11-Gen.

February 2015

DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the equipment of Sulphur Recovery Units (Claus, SCOT and incineration).

Typical refractory lined equipment are:

- Claus burner (main burner) and main reaction chamber,
- the inlet tube sheet and outlet channel of the waste heat boiler,
- line burner(s),
- reactors,
- condensers,
- SCOT burner and reaction chamber,
- incinerator,
- flue ducting and stack.

This DEP is applicable to new and existing equipment within the sulphur recovery unit.

This DEP focuses on lining designs for equipment in sulphur plants. This DEP has to be used in combination with the generic DEPs on refractory bricks and refractory concretes (see below). In case of conflict, this DEP has precedence over the following generic material DEPs.

DEP 44.24.32.30-Gen.	Unshaped refractory materials for monolithic refractory linings
DEP 44.24.32.31-Gen.	Classification of unshaped refractory lining materials
DEP 44.24.32.32-Gen.	Specification for sampling and testing of unshaped refractory lining materials
DEP 44.24.32.33-Gen.	Specification for anchoring systems of unshaped refractory lining materials
DEP 64.24.32.31-Gen.	Construction details for refractory brick construction
DEP 64.24.32.33-Gen.	Guidelines for curing, drying and firing of unshaped refractory lining materials
DEP 64.24.32.34-Gen.	Refractory contractor selection and applicator qualification for installation of unshaped refractory lining materials
DEP 64.24.32.35-Gen.	Construction design details of unshaped refractory materials
DEP 44.24.90.31-Gen.	Refractory bricks and shapes
DEP 44.24.90.32-Gen.	Classification of refractory bricks and shapes
DEP 44.24.90.33-Gen.	Specification for sampling and testing of refractory bricks and shapes
DEP 44.24.90.34-Gen.	Classification specification and testing of ancillary materials for refractory brick construction
DEP 44.24.90.35-Gen.	Specification and quality control for precast or specialty cast refractory baffle wall tile (shapes)

This is a revision of the DEP of the same number dated February 2011; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to sulphur recovery units. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Refractory Manufacturer** is the party that manufactures the refractory products and/or ancillaries for supply to the Refractory Contractor. The Refractory Manufacturer has primary responsibility for material design properties, manufacturing quality control at the manufacturing site, construction design requirements and specific procedures such as those for site product mixing, installation and curing, drying, firing and start-up. The refractory Contractor may undertake duties of the Refractory Manufacturer only if they are the actual manufacturer of the product.

The **Refractory Contractor** is the party that undertakes all, or part of, the construction design, engineering, material procurement and application of refractory products on behalf of the Manufacturer where different. The Refractory Contractor has responsibility for the quality control of supplied products along with workmanship quality control as part of the total quality system.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Applicator	The party or individual that applies or installs the refractory linings.
Bricks	Standard sized shapes, typically pressed from high alumina or fireclay mixtures, provided pre-fired with specified geometry and physical property characteristics, also called shaped refractories .
Matrix Wall	Refers to tubesheet linings consisting of specially designed ferrules requiring no matrix unshaped filler material between tube pitches.

Term	Definition
Monolithic Lining	Refers to linings formed from unshaped materials (plastic, castable) without joints other than for designed panels or for control of cracks and expansion.
MRC	Main Reactor Chamber, also called reaction furnace
Refractory Materials, Products and Linings	Dense, insulating, and/or special composite refractory materials made from non-metallic mineral components.
SCOT	Shell Claus Off-Gas Treating process.
Shapes	Typically, non-standard shapes from unshaped materials manufactured in controlled "shop" environment and pre-fired to stability for the intended application.
SRU	Sulphur Recovery Unit
Unshaped Refractory	Refractory material supplied in unfired state ready for installation into monolithic construction also called monolithic refractories .
WHB	Waste Heat Boiler

1.3.3 Abbreviations

Term	Definition
B.D.	Bulk Density
CCS	Cold Crushing Strength
HEC	High Energy Combustion Technologies
IFB	Insulating Fire Brick
LMV	Abbreviation for Duiker type burner
RUL	Refractories Under Load (test)
SD	Shaped Dense
SI	Shaped Insulating
UD	Unshaped Dense
UI	Unshaped Insulating

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (8).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2011. The DEP has had undergone a significant revision, so it is impractical to summarise all the changes. The following are some of the main, non-editorial changes.

Section	Change
	Removal of DEM1 requirement.
	Separate and extended item on thermal design of lining systems.
	Split the lining designs for Claus burner and Main Reaction Chamber on the basis of process temperatures.
	Incorporation of material specifications to align with refractory material classification DEPs.
	Removal of various general items on refractories and refractory installation, which are not specific for sulphur plants and which are covered in the refractory material DEPs.
Appendix A	Reintroduced section on sulphur pits in case of modification to existing units.
References	Added ATSM C181

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://swwww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

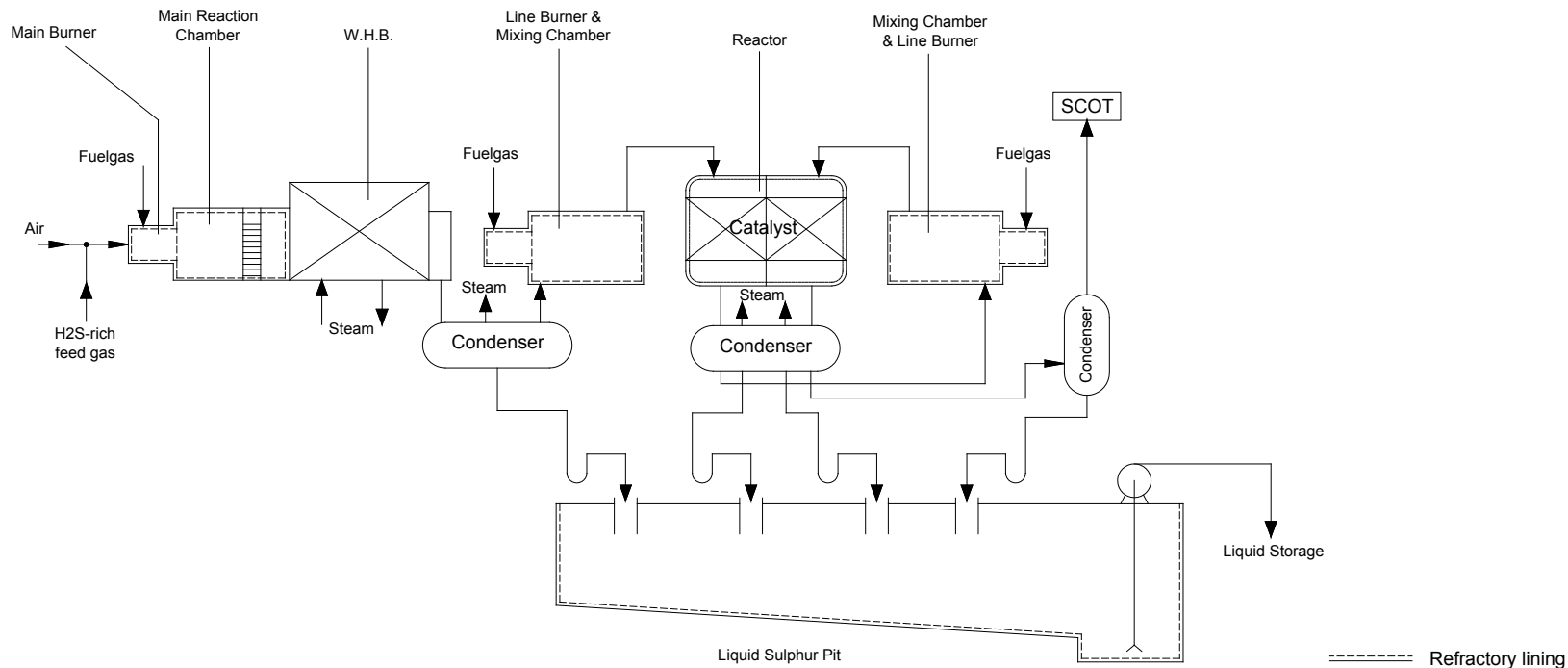
Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. BASIC REQUIREMENTS

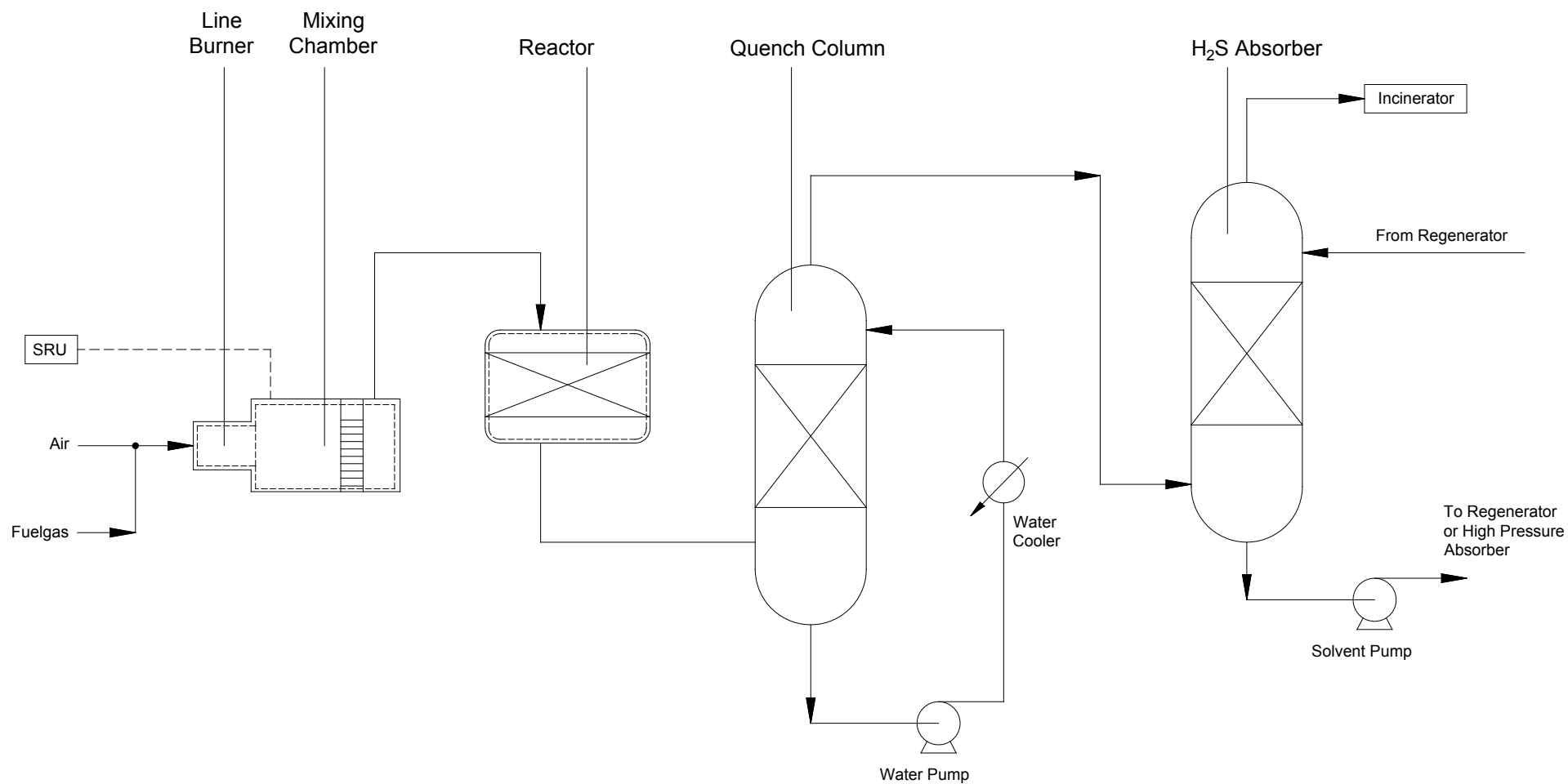
2.1 TYPICAL LAYOUT

1. A typical layout for a SRU is shown in Figures 1, 2, and 3. These figures are for the purpose of illustrating the primary components of the SRU outlined in this DEP.



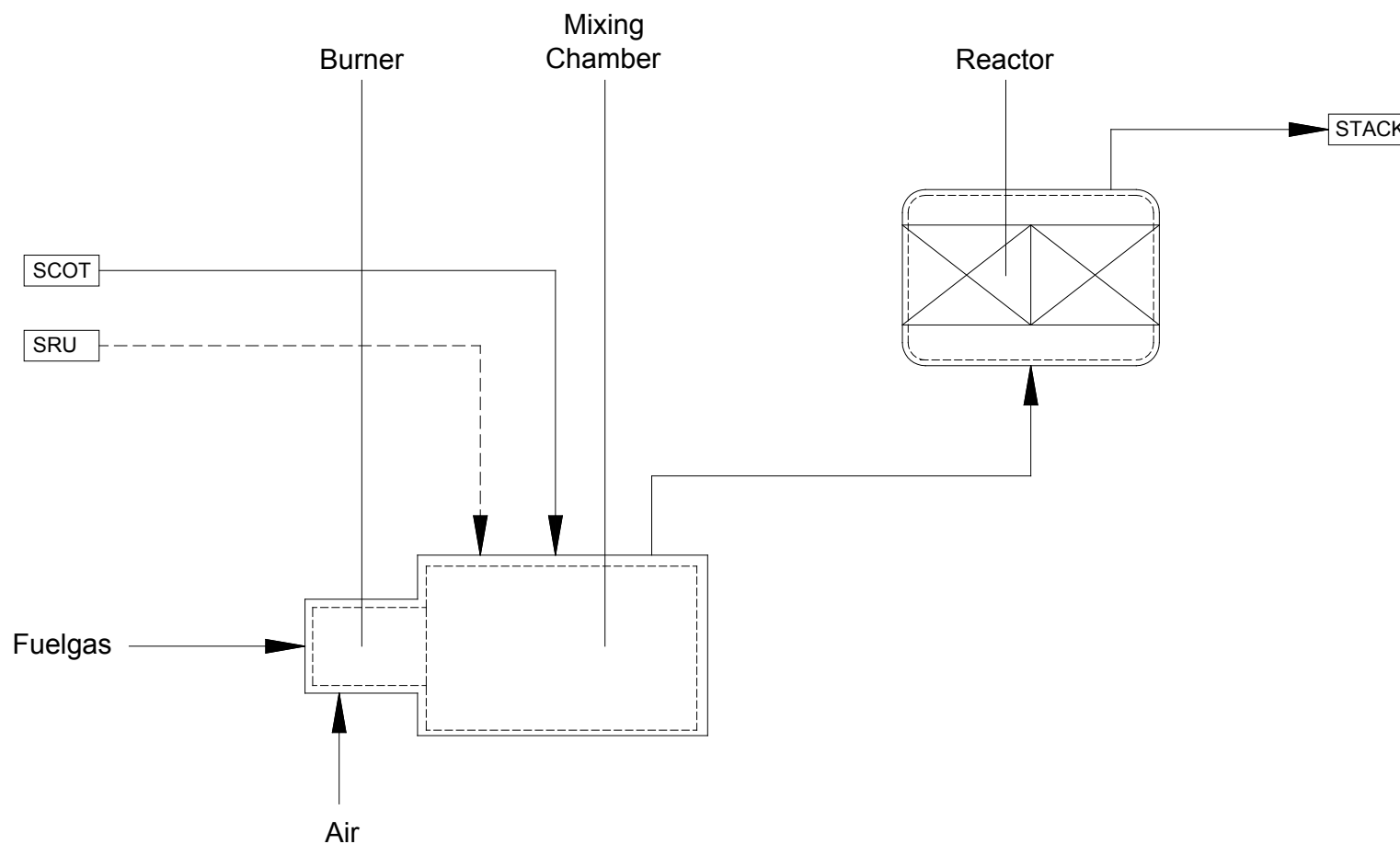
Typical layout CLAUS Unit

Figure 1 Typical layout of a Claus unit



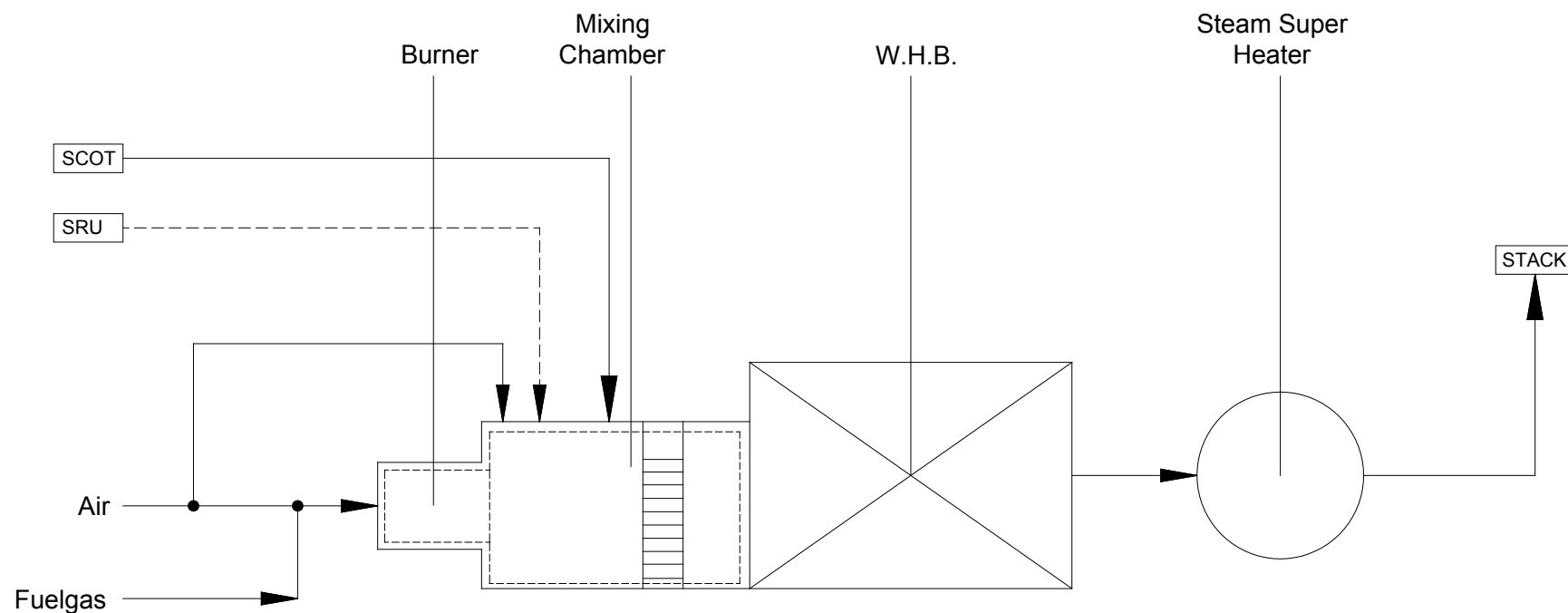
Typical layout of SCOT unit

Figure 2 Typical layout of a SCOT unit



Typical layout of Catalytic Incinerator unit

Figure 3a Typical layout of a catalytic incinerator



Typical layout of Thermal Incinerator unit

Figure 3b Typical layout of a thermal incinerator

2.2 REFRACTORY MATERIAL COMPATIBILITY

1. All refractory lining materials shall be chemically compatible with the process conditions. Materials have to withstand various sulphur species (H_2S , SO_2 , SO_3 and elemental sulphur).
 - a. The Fe_2O_3 content of all hot face layers in equipment operating at temperatures over 400°C (750°F) shall be less than 2 % by weight.
2. Monolithic lining materials shall be rated for an operating temperature of at least 1300°C (2370°F), even if the operating temperature is much lower.
3. For the backup linings, temporarily conditions with temperatures below the acid dew point cannot always be avoided. The minimum quality of insulating firebricks shall be type 26 [1420°C (2600°F)].
4. Type 23 insulating fire bricks (IFB) shall only be allowed as back up material in the back side of LMV burners.
5. For all monolithic materials, the bulk density shall at least be 1.25 gr/cm^3 (80 lbs/ft^3).

2.3 BRICK LININGS

2.3.1 General

1. Insulating and dense refractory bricks shall be in accordance with the series of DEPs concerning refractory bricks.
2. Standard side arch and key bricks should be used in circular and curved areas. The application of straight bricks in these areas shall be avoided. The smallest internal diameter which can be made with standard side arches and or key bricks is 1 m (40 in).
3. For smaller diameters, pre-fabricated shapes or unshaped materials shall be applied.
4. Wedging for side arch and key bricks should be 10 mm (0.4 in) at least.
5. The volume of hot face bricks should preferably not exceed values around 2 dm^3 (0.07 ft^3) in order to facilitate the lining installation.
6. For hot face bricks applied at temperatures over 1000°C (1830°F), heat setting mortar shall be used.
7. If equipment has to be transported after completion of the lining installation, then air setting mortar shall be applied for the hot face lining. Insulating bricks shall be installed with air setting mortar (wet or dry). Bricks joints shall not exceed 2 mm (0.8 in).
8. For high temperature cylindrical vessels, close control of the brick joints during installation is required, since the joints should also provide expansion allowance.
9. Layers of brick may be constructed in bonded or unbound rings; unbound rings shall be half-size or three-quarter-size offset ring to ring.
10. Conical sections should be constructed in fully contacted and corbelled separate rings of either wedges or arches, provided that the diametrical difference is not more than one third of the layer thickness and the backfill is not greater than 50 mm (2 in). Larger transitions may be built up with combinations of carefully engineered wedge and arch bricks forming the required conical shape or from special double tapered bricks.
11. For additional requirements on bricks for the hot face lining in the Claus burner and the main reaction chamber, see (3.2.1).

2.3.2 Classification of bricks for SRUs

1. Cold crushing strength (CCS), refractoriness under load (ISO1893 and/or ASTM C16) and Fe_2O_3 content shall be as defined in Table 2.
 - a. For refractoriness under load, preference is given to the ISO 1893 test; because this test allows higher testing temperatures than ASTM C16.

2. The maximum temperature and Fe_2O_3 content shall be as Table 3.
3. From a mechanical point of view, higher strength insulating firebricks should be considered for high temperature [$>1000^\circ\text{C}$ (1830°F)] equipment where the internal diameter exceeds 2.5 m (8 ft).

Table 2 Dense bricks for SRU linings

			SD-1	SD-2	SD-3	SD-4
ISO	ISO 10081-1		FC-30li	HA55	HA65	HA85
ASTM	ASTM C27			HA60	HA70	HA90
Type			fireclay	Silimanite/ Andalusite	Mullite	Mullite bonded corundum
B.D		kg/m^3	>2200	>2500	>2600	>2950
		lb/ft^3	$>35,250$	$>40,050$	$>41,650$	$>47,250$
CCS		MPa	>35	>70	>70	>90
		psi	$>5,100$	$>10,200$	$>10,200$	$>13,000$
$T_{0.5}$ ¹⁾	ISO 1893	$^\circ\text{C}$	1320	1600	1650	1700
		$^\circ\text{F}$	2400	2900	3000	3100
RUL ²⁾	ASTM C16	%				$< 0.5\%$
Al_2O_3		%	30-35	58-65	68-75	88-95
Fe_2O_3		%	< 1.8	< 1	< 0.5	< 0.5

NOTE: 1) $T_{0.5}$ is the temperature where deformation of the sample reaches 0.5 % for a load of 0.2 MPa (ISO 1893).

2) RUL ASTM C16, refractories under load test, schedule 7, 1650°C (3000°F).

Table 3 Insulating bricks for SRU linings

		SI-1	SI-2	SI-3	SI-4
ISO	2245	Gr 125	Gr 140	Gr150	Gr 160
ASTM	C155	C23	C26	C28	C30
Maximum temperature	$^\circ\text{C}$	1260	1420	1540	1650
	$^\circ\text{F}$	2300	2600	2800	3000
B.D	kg/m^3	480	800	900	1020
	lb/ft^3	7,700	12,800	14,400	16,340
CCS		>0.8	>1.2	>2	>2.5
Al_2O_3		>35	>55	>65	>70
Fe_2O_3		< 1	< 1	< 1	< 1