MANUAL

PREPARATION OF SAFEGUARDING MEMORANDA AND PROCESS SAFEGUARDING FLOW SCHEMES

DEP 01.00.02.12-Gen.

August 1994

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

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1. INTRODUCTION

1.1 SCOPE

This DEP, which is a revision of an earlier DEP with the same title and number dated January 1985, gives requirements and guidance for the preparation of Safeguarding Memoranda (SM) and the Process Safeguarding Flow Schemes (PSFS) to be prepared for each new construction project by the party responsible for the process design and process engineering.

The SM for a unit, and the PSFS (which is an integral part of the SM), shall form part of the Design Book for that particular unit (see also DEP 01.00.02.11-Gen.).

The Principal is responsible for ensuring that the safeguarding of an existing unit is studied and developed before any modification is made to process conditions, equipment, piping or instrumentation.

Changes to the original design should be followed up by a re-assessment of the ultimate level of protection, including the re-sizing of the capacity determining components.

The SM and PSFS shall be updated as an integral part of the plant change procedure.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized by SIPM, the distribution of this document is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company, and to Contractors nominated by them (i.e. the distribution code is "C" as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, gas plants and, where applicable, in chemical plants and exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may 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 as regards 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3. DEFINITIONS

1.3.1 General definitions

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorized to act for the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions and abbreviations

The following definitions shall apply in the context of Safeguarding Memoranda (SM) and Process Safeguarding Flow Schemes (PSFS).

Capacity determining components are elements that when fully open can lead to relief flows exceeding 25% of the design capacity of the particular relief device.

Examples: A control valve and/or its bypass between a high-pressure system and a low-pressure system when it fails open; a capacity reducing restriction.

Hazard is a physical situation with a potential for human injury, loss of equipment or production, or environmental pollution.

Instrumented protective function is a function composed of one or more initiators, an instrumented protective system and one or more actuators for the purpose of preventing hazards.

Instrumented protective system is the (electrical and/or electronic and/or programmable electronic) logic solver component of the instrumented protective function

Mitigating systems are systems or elements that are specifically included in the design to limit the consequences of an uncontrolled loss of containment.

Example: A remotely operated valve in the suction line of a pump.

Penultimate safeguards are instrumented protective functions that provide the penultimate level of protection against uncontrolled loss of containment.

Examples: Instrumented protective functions such as PZA, FZA, LZA and TZA.

(NOTE: These are not normally included in the PSFS).

Safeguarding is protection against uncontrolled loss of containment.

Ultimate safeguards are systems or elements that serve as the ultimate level of protection against uncontrolled loss of containment.

Examples: Relief devices; certain instrumented protective functions, e.g. TZA protection against runaway reactions or overfiring.

Uncontrolled loss of containment occurs when process variables (usually pressure or temperature) exceed limits to such an extent that process equipment fails to contain the process materials. Uncontrolled loss of containment may be due to ruptures, failures of seals, gaskets, welds, etc.

NOTE: Flaring, depressuring and venting are considered to be a controlled loss of containment.

Abbreviations:

FZA: Flow emergency / safety function with alarm
IPF: Instrumented protective function
LZA: Level emergency / safety function with alarm
NRV: Non-return valve
PEFS: Process engineering flow scheme
PSFS: Process safeguarding flow scheme
PZA: Pressure emergency / safety function with alarm
SM: Safeguarding Memorandum
TSO: Tight shut-off
TZA: Temperature emergency / safety function with alarm

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. All publications referenced by this DEP are listed in (5.).

2. GENERAL

2.1 OBJECTIVES

The Safeguarding Memorandum (SM), of which the Process Safeguarding Flow Scheme (PSFS) is an integral part, identifies and summarizes those protective devices (**ultimate safeguards**) which are installed as the ultimate level of protection against uncontrolled loss of containment of toxic and/or flammable materials. It also highlights those additional instrumented protective functions (**penultimate safeguards**) that provide the penultimate level of protection for a process / utility / off-plot unit against uncontrolled loss of containment.

The SM includes the associated **capacity determining components**. It further identifies and clarifies the interfaces with other units and utility systems and as such serves as an aid to readily assess whether process safeguarding provisions could be defeated if possible modifications or extensions of the original process design would be implemented.

For each unit of a project, an SM shall be developed in the course of the design and ultimately included in the Design Book. The SMs should also be incorporated in the Operating Manual, since they provide a useful and important safety and training aid for operating personnel in addition to their general contribution towards plant safety.

2.2 BASIS

The SM and PSFS shall be prepared from the Process Engineering Flow Scheme (PEFS), under the general guidance and responsibility of the process engineers concerned.

The SM and PSFS shall be the result of a thorough investigation of the process design. During this investigation, all events that could result in uncontrolled loss of containment shall be identified and adequate safeguarding and protection measures shall be decided upon.

The details of the instrumented protective functions are described by the process control engineer in the Control and Safeguarding Narratives.

(3) and (4) of this DEP provide the guidelines for what information should be extracted from the PEFS. They shall be followed unless there are overriding reasons for deviating from them. If deviations from these guidelines are applied, the underlying principles behind these deviations shall be recorded in a form that is easily retrievable in case a critical re-examination is needed later.

2.3 TIMING OF PREPARATION

The preparation of the SM and PSFS by the process engineer shall be initiated at the start of the project definition phase.

In the project definition and implementation phases up to and including commissioning of the process concerned, the Project Manager is responsible for updating the SMs and ensuring that interfacing SMs are also updated, if applicable.

The SMs can only be finalized by the process engineer after he has approved the PEFSs from which they are derived.

3. FORMAT OF THE SAFEGUARDING MEMORANDUM

The SM shall be based on the following structure:

Section 1. : Introduction

Section 2. : Ultimate safeguards, Mitigating systems, Penultimate safeguards and Capacity Determining Components

Section 3. : Interfaces with other units

Section 4. : Miscellaneous

For an example, see Appendix 1.

Section 1. Introduction

This section shall be used for the introduction of the subject and for any deviations as specified in (1.2) of this DEP.

Section 2. Ultimate safeguards, Mitigating systems, Penultimate safeguards and Capacity determining components

This section shall be subdivided as follows:

2.1 Ultimate safeguards - Summary of relief valves, rupture disks and instrumented protective functions

This summary shall state tag number, set pressure, service, location and governing case with reference to the appropriate descriptive sections. The summary should be in tabular form (see Appendix 1).

2.2 Ultimate safeguards - Description of individual relief cases

For each relief device, mention shall be made of any associated capacity determining components. A clear description shall be given as to what will happen, together with the resultant relief flows, in the following cases:

1. Electrical power failure
   - 1a. Total power failure
   - 1b. Single power failure
   - 1c. Partial power failure (failure of a single cable, transformer or circuit breaker)
2. Total cooling water failure
3. Total instrument air failure
4. Inadvertent valve opening
5. Blocked outlet
6. Other failure
7. Fire (*)
8. Thermal expansion

(*) Where a fire insulation (environmental) factor as defined in DEP 80.45.10.10-Gen. of less than 1.0 is used, the reason(s) for doing so shall be stated.

The description of each relief case shall be preceded by a code composed as follows:

2.2.x.y

where x = Sequence number of the relief case

and y = Sequence number of the relief device from the summary of relief devices

See Appendix 1 for an example.

2.3 **Ultimate safeguards - Description of instrumented protective functions**

Instrumented protective functions are applied as ultimate safeguards where the use of relief devices is impossible or impractical.

A description shall be given of the design intent and action, including any restrictions which may be present.

2.4 **Mitigating systems - Description of remotely operated valves (ROVs), emergency shutdown (ESD) and emergency depressuring (EDP) systems, emergency dump systems, water spray / deluge systems, etc.**

These are mitigating systems or elements provided for use in emergency situations such as a large release of a flammable and/or toxic substance as a result of catastrophic failure of process equipment, leading to an uncontrollable fire, an explosion or dispersion of a toxic cloud.

2.5 **Penultimate safeguards - Description of instrumented protective functions**

This section should cover the instrumented protective functions providing the penultimate level of protection against loss of containment. Systems installed for equipment protection purposes shall therefore be excluded.

These penultimate safeguards shall not appear on the PSFS.

For each of these instrumented protective functions, a description shall be given of its design intent and action including any restrictions which may be present.

For complex safeguarding systems (e.g. of furnaces), it may be appropriate to refer to the relevant section elsewhere in the project documents, e.g. the Basic Design and Engineering Package, Project Specification or Design Book.

Section 3. Interfaces with other units / systems.

Interfaces with upstream/downstream units, utility systems and off-plot systems shall be examined in detail to assess what effects the particular unit or system can have on any other unit or system and vice versa. This examination shall include knock-on effects which may emerge when failure of a utility system in one particular unit would induce failure of one or more utility systems in other units or systems, thereby causing an additional load on the flare and relief system.

Adequate protection shall be provided against events like product breakthrough from high pressure to low pressure systems, temperature excursions due to heat exchange-failure, etc.

This section shall also include facilities installed for positive isolation between shutdown blocks, such as spectacle blinds.

Section 4. Miscellaneous

This section shall cover those aspects of the process safeguarding procedure not addressed in the previous sections of the SM.

It could, for example, include a description of the design intent of the following items:

- special features to avoid blockage of relief valve inlets / outlets (heat tracing / insulation, on-plot flare knock-out vessels, purging / flushing facilities, rupture disks, etc.).
- facilities for on-stream testing of ultimate safeguards.
- the interlocking system for block valves of relief devices.
- the method of identifying capacity determining components in the field.
- non-return valves forming part of an ultimate safeguard which have to be periodically tested, and the method of identifying these non-return valves in the field.
- gas detection equipment (H_2S, HF, hydrocarbons, etc.).

4. FORMAT OF THE PROCESS SAFEGUARDING FLOW SCHEME

In its simplest form, the PSFS should show only the ultimate safeguards and mitigating systems with the associated capacity determining components. Penultimate safeguards and systems protecting equipment are not normally included.

The PSFS therefore shows:

(a) Ultimate safeguards:

- relief valves
- rupture disks
- thermal expansion valves; however, those for pumps and those in cooling water service may be deleted.
- instrumented protective functions

NOTE: Items/provisions which are essential to the proper functioning of the ultimate safeguards shall also be shown. Examples are steam tracing of relief lines or secured air supplies.

(b) Capacity determining components:

- trip valves, control and bypass valves, and restricting devices which upon inadvertent opening can lead to relief flows in excess of 25% of the design capacity of the relief device.

  For each control valve shown, the PSFS shall indicate spring action, stay-put device, minimum stop, etc.

(c) Mitigating systems

- emergency depressuring or shutdown valves; spring action shall be indicated.
- remotely operated valves (ROVs) which are installed specifically for handling emergency situations.

(d) the relevant interfaces with other units or systems, including the utilities and the flare and relief systems, in order to focus attention on the effect one particular unit or system may have on another unit or system upon equipment failure, process deviations or operational errors.

If the interface with another unit includes capacity determining components, these components shall also be shown. For an example, see (Appendix 2B).

4.1 LAYOUT

4.1.1 Single sheet concept

The PSFS format closely resembles that of a Process Flow Scheme.

Wherever possible, the PSFS for a unit, including its relevant tie-ins with other units, shall be confined to one sheet unless the excessive amount of information presented would be confusing. The use of a single sheet will improve the understanding of unit interactions. Interface details between units may appear more than once, i.e. on the PSFS of each unit.

4.1.2 Cross-referencing

The nature of incoming and outgoing process streams should be shown in boxes at the edges of the sheet with arrows indicating the direction of flow. The origin or destination of the stream (unit name or equipment item number) should also be stated in the box.

4.1.3 Equipment and lines

All numbered items of equipment, and major process lines, should be indicated.

Multiple equipment items (spares, parallel) should be indicated by one symbol. The equipment item number can indicate multiplicity by the use of A, B, C etc. as postscript.

Major process lines are those indicating the path of the main process stream(s) through the processing plant.

Start-up lines, recycle lines and bypass lines shall be shown only if they include a capacity determining component and/or would influence the ultimate level of protection against uncontrolled loss of containment.

4.1.4 Symbols

Symbols and identification shall be in accordance with DEP 31.10.03.10-Gen. and DEP 32.10.03.10-Gen. Basic symbols usually suffice for heat transfer equipment and furnaces. The more elaborate symbols should be used for e.g. pumps, compressors, columns and vessels.

It is common practice to indicate - sparingly and schematically - some details of column and vessel internals to clarify their function, for example:

- partial and total draw-off trays
- packed sections
- baffles, sumps
- demister mats

Diamonds containing a designation of the utilities, e.g. low, medium and high-pressure steam, condensate, fuel gas, caustic soda, nitrogen and also designations for flare, H_2S flare, hydrocarbon drains, etc. contribute greatly to the legibility of the scheme and should therefore be used.

5. REFERENCES

In this DEP, reference is made to the following publications:

NOTE: Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Compilation of design books	DEP 01.00.02.11-Gen.
Symbols and identification system - Mechanical	DEP 31.10.03.10-Gen.
Symbols and identification system - Instrumentation	DEP 32.10.03.10-Gen.

APPENDICES

Appendix 1	Example -	Safeguarding Memorandum for Kero HDS Unit
2A	Example -	Process -Safeguarding Flow Scheme for the reactor section of the Kero HDS Unit
2B	Example -	Process Safeguarding Flow Scheme for Sour Water Stripper Unit

APPENDIX 1 KERO HDS UNIT SAFEGUARDING MEMORANDUM

1. Introduction

This memorandum describes the relief devices and safeguards by instrumentation provided against loss of containment in the kerosene hydrodesulphurization unit at ABC refinery. This unit shall henceforth be referred to as the 'Kero HDS' unit.

The PSFS only shows instrumentation that is related to uncontrolled loss of containment.

This memorandum is intended to be part of the design book and it will also be included in the operating manual. It shall be duly updated when plant modifications are implemented.

The locations of the relevant relief devices and instrumented protective functions are shown on the PSFS Drawing No. x.xx.xx.xxx.

This memorandum and related process safeguarding flow scheme have been prepared using DEP 01.00.02.12-Gen., "Preparation of safeguarding memoranda and process safeguarding flow schemes".

No national or local regulations exist, and accordingly the DEP requirements are fully met.

The PSFS principally shows:

- safeguarding systems, i.e.
  - ultimate safeguards: all systems or elements that serve as the ultimate level of protection against uncontrolled loss of containment, e.g. relief valves, rupture disks and instrumented protective functions;
  - mitigating systems: all systems or elements that are specifically included in the design to limit the consequences of an uncontrolled loss of containment, such as ROVs in pump suction lines;
  - capacity determining components: all elements that when fully open can lead to relief flows exceeding 25 % of the design capacity of the particular relief valve.
- interfaces with upstream/downstream units or systems.

2. Ultimate safeguards, Mitigating systems, Penultimate safeguards and Capacity determining components

2.1 Ultimate safeguards - Summary of relief devices and instrumented protective functions

2.1.1 Summary of relief valves and rupture disks

Tag no.	Set press. bar (ga)	Service	Location	Governing relief case
RV-1/11	51.4	K-1/1S	Discharge	Blocked Discharge
RV-2/21	51.4	K-2/2S	Discharge	Blocked Discharge
RV-3	6.8	V-5	Top mounted	Fire
Etc. for all other relief valves and rupture disks				

2.1.2 Summary of instrumented protective functions

Tag no.	Location	Purpose
PDZA-1/FZA-1	Discharge feed pump	Backflow Protection
TZA-1-HH	Outlet Furnace	Overheating Protection
Etc. for all other instrumented protective functions		

2.2 Ultimate safeguards - Description of individual relief cases

2.2.1 RV-1/11 Discharge of Compressor K-1/1S

In the case of a valve in the discharge of the compressor being closed (or a blockage in the reactor), the gas will be relieved. The relief quantity is equal to the maximum capacity of the compressor, and this is the determining case.

2.2.1.1 Electrical power failure

a) General - Compressor stops and no relief takes place.

b) Single - Compressor stops and no relief takes place.

c) Partial - Compressor stops and no relief takes place.

2.2.1.2 Total cooling water failure

Not applicable.

2.2.1.3 Total instrument air failure

Fresh gas supply shuts and compressor trips on low suction pressure. Therefore no relief takes place.

2.2.1.4 Inadvertent valve opening

Not applicable.

2.2.1.5 Blocked outlet

Determining case, as described in section 2.2.1 above.

2.2.1.6 Other failure

Not applicable.

2.2.1.7 Fire

Not applicable.

2.2.1.8 Thermal expansion

Not applicable.

2.2.2 RV-2/21 Discharge of Compressor K-2/2S

In the case of a valve in the discharge of the compressor being closed or a blockage in the reactor, the gas will be relieved. The relief quantity is equal to the maximum capacity of the compressor, and this is the determining case.

2.2.2.1 Electrical power failure

a) General - Compressor stops and no relief takes place.
b) Single - Compressor stops; initiating other shut downs, but no relief takes place.
c) Partial - Compressor stops; initiating other shut downs but no relief takes place.

2.2.2.2 Total cooling water failure

Not applicable.

2.2.2.3 Total instrument air failure

Not applicable.

2.2.2.4 Inadvertent valve opening

Not applicable.

2.2.2.5 Blocked outlet

Determining case, as described in section 2.2.2 above.

2.2.2.6 Other failure

Not applicable.

2.2.2.7 Fire

Not applicable.

2.2.2.8 Thermal expansion

Not applicable.

2.2.3 Etc. for all other relief valves and rupture disks

2.3 **Ultimate safeguards - Description of instrumented protective functions**

2.3.1 FZA-1 : acts upon low low kerosine flow.

PDZA-1 : acts upon low pressure drop across FRCA-1 and PdZA-1.

Purpose : To prevent back-flow to the feed surge vessel. FZA-1 is fitted with an operational override which shall only be used during hot hydrogen stripping or decoking.

Trip action: Shut down of feed pump P1/1-S, closure of the TSO valve and control valve of FRCA-1, and shutdown of the furnace.

2.3.2 TZA-1-HH : High high furnace outlet/reactor inlet temperature.

Purpose : to prevent overheating of equipment and to minimize the chance of initiating a temperature runaway in the reactor

Trip action: Shut down of fuel to furnace F1.

2.3.3 ..... : Description of other instrumented protective functions

2.4 **Mitigating systems - Description of remotely operated valves, emergency shutdown and emergency depressuring systems, emergency dump systems, water spray / deluge systems, etc.**

2.4.1 High rate depressuring valve - HZ-2

HZ-2 is a spring to open TSO valve located on the H.P. separator (V1). This system is initiated manually from the panel and it is capable of depressuring the reactor section under fire conditions to 7 bar (ga) in 15 minutes.

The initiation of depressuring stops fresh feed, fresh gas and trips the furnace.

2.4.2 Low rate depressuring valve - HIC-1

HIC-1 is a spring to close TSO valve located on the H.P. separator (V1) and is capable of depressuring the reactor section to 7 bar (ga) in 60 minutes. The valve can be used to maintain gas-flow in the reactor in the case of a low gas-rate thus minimizing the chance of a temperature runaway and could therefore be used if TZA-1 has been activated.

2.4.3 .....: Description of other mitigating systems

2.5 **Penultimate safeguards - Description of instrumented protective functions**

It should be noted that this section does not cover safeguards by instruments installed for equipment protection, e.g. compressors, pumps or furnaces.

2.5.1 .....: Description of all penultimate safeguards

3. **Interfaces with other units**

Relief facilities on connected units should, where appropriate, each be able to cope with back-flow and failure of the interface barrier. This will be discussed below for each interface.

3.1 Interface with the feed supply

Backflow into the feed surge vessel of the feed pump (P1) is adequately prevented by PDZA-1 and FZA-1 acting on the separate TSO and FRCA-1 valves and by the NRV in the pump discharge. RV-3 is not sized for the backflow of material through P1 since this would be highly impractical.

3.2 Interface with the fresh gas supply system

The relief valve (RV-7) on V-3 has been sized to give protection against fail open of the barriers between V-3 and the recycle gas system. This relief valve will similarly protect the fresh gas supply system which has the same design pressure.

The relief valve (RV-3) on V-5 has been sized to give protection against fail open of the barrier between V-5 and the fresh gas supply system. The design pressure of V-5 is lower than that of the fresh gas supply system.

3.3 Typically the following interfaces would be described in a similar manner:

- Utilities systems
- Flare System
- Work-up section
- Sour-water disposal system
- Low pressure separator / off-gas treater
- Feed surge drum / Crude unit
- Etc.

NOTE: Interfaces 1 and 2 have been defined at the feed pump and fresh gas compressor. Alternatively, and strictly more correctly, the interfaces should be defined as the unit limits as shown on the PSFS. In this case backflow through P1/1-S would be described under section 3.3.

4. **Miscellaneous**

A number of safeguarding aspects which have not yet been mentioned are discussed below.

4.1 Relief devices/piping

Relief devices shall be located above the header into which they discharge. The upstream piping shall slope down towards the protected equipment and the downstream piping shall slope down towards the flare header.

Steam tracing of piping upstream and downstream of the relief device has been applied where fouling/plugging of these lines cannot be excluded, due to possible deposition of salts.

4.2 Operation of interlocking systems

In normal operation, the interlocking system provided for the block valves of the relief valve is arranged such that the inlet block valve of the open dummy on the spare position is closed and the block valve on the outlet is open, because the pressure rating of the outlet is lower than that of the inlet.

Changeover is accomplished in the following sequence:

1. the inlet block valve of the spare relief valve is opened and locked
2. the inlet of the relief valve to be removed is closed
3. the outlet of the relief valve to be removed is closed
4. the removed relief valve is replaced by a spool piece (dummy)
5. the outlet block valve of the dummy is opened and locked

4.3 Capacity Determining Components

Control and bypass valves and capacity reducing restrictions which determine the size of relief valves shall be provided with a red tag in the field, showing that the component affects the size of the relief valve indicated.

4.4 Non-return valves

The non-return valves shown on the PSFS which are part of the safeguarding systems shall be inspected during planned maintenance shutdowns.

4.5 Drains of LG's and LT's

The drain valves of LG's and LT's on vessels V1, V3 and V4 have been hard-piped to the LP-separator (V2) in order to avoid the release of toxic material when carrying out routine draining of the LG's and LT's.

4.6 Etc.

5. Process Safeguarding Flow Schemes

Process Safeguarding Flow Scheme for the Reactor Section of the Kero HDS Unit

Process Safeguarding Flow Scheme Sour Water Stripper Unit (Typical)

APPENDIX 2A ALSO, PROCESS SAFEGUARDING FLOW SCHEME FOR THE REACTOR SECTION OF THE KERO HDS UNIT

APPENDIX 2B PROCESS SAFEGUARDING FLOW SCHEME FOR SOUR WATER STRIPPER UNIT