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GP 78-11

Subsea Chemical Injection System Design and Operation

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

The original GP was issued as an Engineering Technical Practice (ETP) that addressed ESP Current Predictions and Troubleshooting Guidelines.

This Engineering Technical Practice (ETP) GP 78-11 is the first issue to address Subsea Chemical Injection System Design and Operation.

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Table of Contents

Foreword	2
1. Scope	5
2. Normative references.....	5
3. Terms and definitions.....	6
4. Symbols and abbreviations.....	8
5. SCIS general project execution requirements and recommendations	9
5.1. Project responsibilities, lines of communication, and competency.....	9
5.2. SCIS system functional requirements specification	11
5.3. SCIS system design calculation package.....	17
6. Detailed SCIS design guidelines	19
6.1. Introduction.....	19
6.2. Generic SCIS design guidelines.....	19
6.3. Type 'A' subsea chemical injection system design guidelines	31
6.4. Type 'B' subsea chemical injection system design guidelines	35
6.5. Type 'C' subsea chemical injection system design guidelines	40
6.6. Type 'D' subsea chemical injection system design guidelines	44
6.7. Type 'E' subsea chemical injection system design guidelines	49
6.8. Additional downhole SCIS design guidelines	54
7. SCIS operational guidelines.....	59
7.1. Documentation to be delivered to operations on system handover	59
7.2. Maintenance of previous design documentation	59
7.3. Chemical injection system operational usage logs and other operational data	59
7.4. Re-calibration of SCIS instrumentation	60
7.5. SCIS routine system leak testing	60
7.6. Maintenance of Required System Chemical Cleanliness Levels.	60
7.7. Planned chemical change- out management of change procedures	60
Annex A (Normative) Guidance on interpretation of relevant international specifications	62
A.1. ISO 13628 part 5 - subsea umbilicals	62
A.2. ISO 13628 part 6 - subsea production control systems.....	62
Annex B (Informative) Description and categorisation of suitable SCIS architectures	64
B.1. Definition of a subsea chemical injection system (SCIS).....	64
B.2. Viable SCIS architecture categories.....	64
B.3. Type 'A' architectures – surface pressurisation and surface active flow control.....	68
B.4. Type 'B' architectures – surface pressurisation, surface active flow control and additional subsea passive flow control	70
B.5. Type 'C' architectures – surface pressurisation and subsea active flow control.....	73
B.6. Type 'D' architectures – surface pressurisation and subsea passive flow control.....	76



B.7. Type 'E' architectures – subsea pressurisation and subsea active flow control.....	80
Annex C (Informative) Specific operating characteristics of key SCIS components.....	83
C.1. Introduction.....	83
C.2. Topsides positive displacement pumps.....	83
C.3. Topsides constant pressure pumps	83
C.4. Subsea pumps.....	84
C.5. Surface AFCV.....	85
C.6. Subsea AFCV.....	86
C.7. Subsea PFCV.....	87
C.8. Subsea flow meters	89
C.9. Subsea chemical injection non-return check valves	90
C.10. Downhole chemical injection non-return check valves (DCIV).....	90

List of Tables

Table B.1	SCIS Architectural configuration comparative application ranking.....	67
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List of Figures

Figure 1	Type 'A' SCIS subsea pressure relationships.....	32
Figure 2	Type 'B' SCIS subsea pressure relationships.....	37
Figure 3	Type 'C' SCIS subsea pressure relationships	42
Figure 4	Type 'D' SCIS subsea pressure relationships	46
Figure 5	Type 'E' SCIS subsea pressure relationships.....	51
Figure 6	Potential distributed architecture configuration featuring a redundant solvent flush/contingency duty line	58
Figure B.1	Typical SCIS architectural configurations.....	66
Figure B.2	Type 'A' equivalent SCIS layouts	69
Figure B.3	Type 'B' equivalent SCIS layouts	72
Figure B.4	Type 'C' equivalent SCIS layouts.....	75
Figure B.5	Type 'D' equivalent SCIS layouts.....	79
Figure B.6	Type 'E' equivalent SCIS layouts	81



1. Scope

This Group Practice is applicable to the design, construction and delivery of Subsea Chemical Injection Systems (SCIS) delivered as part of an overall Subsea Production System.

This GP is intended to be of assistance to individuals involved in the identification, specification and delivery of a Subsea Chemical Injection System.

This GP highlights the importance of the SCIS as part of an overall Subsea Production System particularly in areas of deepwater developments where Flow Assurance issues and risks can become significant.

2. Normative references

The following referenced documents may, to the extent specified in subsequent clauses and normative annexes, be required for full compliance with this GP:

- For dated references, only the edition cited applies.
- For undated references, the latest edition (including any amendments) applies.

BP

GP 36-20	Materials Selection and Specification for Subsea Equipment.
GP 78-03	Achieving Reliability in Subsea Projects.
GP 78-04	Reliability Techniques for Subsea Projects.
GP 78-05	Onshore Testing Guidelines for subsea Equipment (FAT, EFAT and SIT).
GP 78-06	Qualification of Technology for Subsea Projects.
GN 36-003	Guidance on Non-Metallic Materials Selection.
GN 36-004	Best Practice for Selection of Materials for Downhole Equipment.
GN 36-007	Guideline for Compatibility Testing of Non-Metallic Materials within Subsea Chemical delivery Systems.
Strategy Guide	BP Subsea Reliability Strategy - A Guide for BP Leaders.

American Petroleum Institute (API)

API Spec 17E	Specification for Subsea Umbilicals - Third Edition/ ISO 13628-5 Adoption.
API Spec 17F	Specification for Subsea Production Control Systems - Second Edition.

British Standards Institute (BSI)

PD 8010-2	Subsea Pipelines Code of Practice.
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Engineering Equipment and Materials Users Association (EEMUA)

EEMUA 194	Guidelines for Materials Selection and Corrosion Control for Subsea Oil and Gas Production Equipment.
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International Organization for Standardization (ISO)

ISO 13628-4	Design and operation of subsea production systems – Part 4 Subsea wellhead and tree equipment.
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ISO 13628-5	Design and operation of subsea production systems – Part 5 Subsea control umbilicals.
ISO 13628-6	Design and operation of subsea production systems – Part 6 Subsea production control systems.
ISO 13628-8	Design and operation of subsea production systems – Part 8 ROV interfaces on subsea production systems.

3. Terms and definitions

For the purposes of this GP, the following terms and definitions apply:

Active flow control valve

A device that positively maintains a constant chemical flowrate in real time irrespective of other operating variables.

Typically provided by a hydraulic/mechanical device with an internal hydraulically balanced flow control valve. Both surface and subsea variants are available.

Batch injection

A system in which chemicals are periodically rapidly injected into the process flow and where the total quantity of injected chemical is more relevant than the instantaneous injection rate.

Typically characterised by the requirement to ensure a bulk quantity of chemical is rapidly injected prior to (or during) an “event” (i.e. well start-up or shut-down).

Continuous injection

A system in which a continuous flow of chemical is required to be injected into the process flow and where a constant chemical flowrate is most relevant.

Frequently characterised by the requirement to ensure that the correct chemical dosage rate is constantly injected into the process flow.

Design pressure

Defined as the gauge pressure on which a component’s design criteria are based.

Relevant to individual components rather than a complete system. Particularly relevant to components specifically covered by ISO 13628 Part 6 which defines a Design Pressure of 110% of the MWP.

Design working pressure (DWP)

Specifically defined in ISO 13628 Part 5 as the “maximum working pressure (gauge pressure) at which an umbilical hose or tube is rated for continuous operation” and that is therefore used to design the relevant umbilical core.

Relevant only to umbilical cores and individual components specifically covered by ISO 13628 Part 5. Normally equal to the MWP.

Direct system

A sub-group of SCIS architecture types where a single transportation conduit (umbilical core) extends from the topsides equipment to a single subsea injection point.

In a direct system each subsea injection point is supplied with chemical via a single dedicated transportation conduit from the surface.



Distributed system

A sub-group of SCIS architecture types where a single transportation conduit (umbilical core) extends from the topsides equipment to a multiple number of concurrently operating subsea injection points.

A key caveat for Distributed Systems is that simultaneous (concurrent) injection should be possible at the multiple subsea injection points.

A system featuring multiple potential subsea injection points but that is only capable of injection into a single point at any one time is, effectively, a Direct System.

Downhole injection

A system with injection points required at downhole sub-surface locations.

Typically delivering Scale Inhibitor into the well production tubing.

Gauge pressure

A pressure level defined *relative* to the local ambient pressure.

The local ambient pressure may be either atmospheric or the local subsea ambient pressure created by seawater static head.

Maximum allowable operating pressure (MAOP)

Specifically defined by pipeline codes as the maximum continuous pressure (gauge pressure) at which a system can be operated in normal conditions at any point along the pipeline.

Has relevance for chemical supply pipelines (or process pipelines into which chemicals are being injected) where it will reflect (or define) the normal MWP set by internal CIU pressure limiting device(s).

Maximum working pressure (MWP)

Defined in this GP as the maximum continuous pressure (gauge pressure) at which an overall system (SCIS) can operate and deliver a production chemical into the process flow in normal conditions.

Defined by active pressure controlling devices in the CIU (pressure regulators and/or pressure transmitter trip limits) that control and limit the CIU output pressure to (or below) this value in normal operation.

Passive flow control valve

A device featuring a flow restriction that can be either fixed or adjustable (either manually or, potentially, by a closed-loop logic controller) that maintains the average flowrate within an acceptable operational band. The instantaneous flowrate is **always** subject to the effects of changing external operating variables (i.e. upstream and downstream pressures and/or adjustment of in-parallel further PFCV's).

A wide group of devices, covering fixed orifices, manually selectable multiple orifices, manually adjustable variable flow restrictions and remotely adjustable electro-hydraulic variable flow restrictions. Not considered suitable for surface flow control applications.

Rated working pressure (RWP)

Specifically defined in ISO 13628 Part 4 for Trees as the “maximum internal pressure (*that the Tree*) equipment is designed to contain and/or control”.



Normally only relevant to SCIS equipment downstream of the Tree pressure controlling components (isolation/non-return valves). Normally equal to or in excess of the MWP.

Subsea chemical injection system

A system that introduces production chemicals into a process flow stream to address flow assurance delivery issues (hydrate formation, paraffin, wax and/or asphaltene depositions, scale formation, flow improvement, separation, slugging mitigation etc.) or to inhibit adverse corrosion effects between produced fluids and the subsea equipment infrastructure (i.e., pipelines/flowlines/risers etc.)

Subsea flow control

A method whereby the flow of chemical into a subsea injection point is controlled by a dedicated flow control device located immediately upstream.

Typically characterised by the use of active or passive subsea flow control valves in either Direct or Distributed Systems.

Subsea pressurisation

The action of a local subsea pump elevating the subsea chemical pressure to a level equal to or exceeding the process flow pressure to allow chemical injection to occur.

This will still require a topsides located pump to deliver a suitable chemical supply flow along the transportation conduit.

Surface pressurisation

The action of a topsides located pump elevating the subsea chemical pressure to a level equal to or exceeding the process flow pressure to allow chemical injection to occur.

Should also include sufficient pressure to maintain the required chemical supply flow along the transportation conduit.

4. Symbols and abbreviations

For the purpose of this GP, the following symbols and abbreviations apply:

AFCV	Active flow control valve.
CIMV	Chemical injection metering valve.
CIS	Chemical injection system.
CIU	Chemical injection unit.
CIV	Chemical injection valve.
CRA	Corrosion resistant alloy.
Cv	Flow coefficient.
CVP	(BP) Capital value process.
DCIV	Downhole chemical injection valve.
DCS	Distributed control system.



DWP	(Umbilical) Design working pressure.
EPC	Engineering, procurement and construction.
FMECA	Failure modes, effects and criticality analysis.
IRCD	Injection rate control device.
MAOP	Maximum allowable operating pressure.
MPcp	(BP) Major project common process.
MWP	(SCIS) Maximum working pressure.
OEM	Original equipment manufacturer.
PFCV	Passive flow control valve.
PLC	Programmable logic controller.
PSV	Pressure safety valve.
MOC	Management of change.
R&M	Reliability and maintainability.
RAM	Reliability, availability and maintainability (analysis).
ROV	Remotely operated vehicle.
ROT	Remotely operated tooling.
RWP	Rated working pressure.
SCIS	Subsea chemical injection system.
SIT	Site integration testing.
SPS	Subsea production system
SPCS	Subsea production control system.
TVD	True vertical depth.
WHSIP	Wellhead shut-in pressure.
XHPHT	Extreme high pressure high temperature.

5. SCIS general project execution requirements and recommendations

5.1. Project responsibilities, lines of communication, and competency

- a. Each SCIS should be considered as an integral sub-system designed to provide specific functionality within an overall subsea production system.



- b. It should not be sub-divided and/or amalgamated into other sub-systems (e.g., it should not be automatically amalgamated and subsumed within the subsea production control system).
- c. Within the BP project team, specific responsibility for delivery of the SCIS should be allocated to one or more team members.
- d. Clear lines of communication should be established between the BP SCIS responsible project member(s) and the following BP group and project resources:
 - 1. BP production chemistry group.
 - 2. BP flow assurance group.
 - 3. BP project representative(s) responsible for the subsea production control system, subsea umbilicals, trees, manifolds and/or flowlines/pipelines (for component design and physical interface management).
- e. Design of the SCIS is a single overall process. Delivery of the SCIS system comprises a range of components from different vendors and potentially different contracted bodies. The only place this comes together is within the project. Absolute clarity in the definition of the scope of each package, performance verification of that package, and the Interface between each package; is the responsibility of the project, and should be delivered by the “subsea system” responsible engineer.
- f. Further the requirements for verifying the correct overall design, and theoretical performance of the SCIS is the responsibility of the project “subsea system” engineer. This should be a nominated BP project team member.

Contractors normally only assume specific SCIS system design verification responsibility within the scope of EPC style contracts. In this context system design verification responsibility normally involves co-ordinating the specification of numerous key equipment items supplied by various vendors, and defining, collating and controlling key design input parameters that influence overall system performance.

- g. The SCIS system responsible project personnel (both BP and, potentially, SCIS responsible contractor personnel) should fully and explicitly define the key equipment types, dimensions and/or functionality that require collation, analysis and decision-making during the project’s MPcp phases, particularly Execute. This should include the following non-exhaustive items:
 - 1. System architecture and configuration (including redundancy and fault-isolation provision).
 - 2. MWP.
 - 3. Acceptability of intended chemical(s) physical properties (e.g. viscosity and Specific Gravity).
 - 4. Bulk and “ready-for-use” CIU storage capacities.
 - 5. Chemical cleanliness issues (i.e., offline filtration requirements, in-line surface and subsea filter requirements, ratings and sizing).
 - 6. All chemical injection conduit sizing (including topsides piping/tubing sizing, umbilical core sizing, manifold piping/tubing sizing, tree piping/tubing sizing, inter-connecting flying lead core sizing, downhole tubing sizing, etc.)
 - 7. Production profiles for early, mid and late life conditions.
 - 8. Topsides pump performance characteristics.
 - 9. Subsea AFCV or PFCV type, manufacturer and performance characteristics.



10. Chemical injection check valve settings (cracking pressures).
11. Downhole chemical injection valve settings (cracking pressures).
12. Chemical and equipment material compatibility (primarily the requirement to develop and maintain an SCIS acceptable materials list and a system materials map).
- h. The SCIS system responsible project personnel should be competent in the field of SCIS technology.

There are project examples where the SCIS has been the responsibility of the project controls engineer, and of the project system engineer. As we create and manage projects under many different regimes the final position of this critical role (controls or system engineering) may vary project to project - selected by that project for the best, least risk project organisation.

5.2. SCIS system functional requirements specification

- a. A SCIS functional requirements specification (alternatively known as basis of design) should be developed by BP to satisfy MPcP and thereafter maintained in a current state. This may be a sub-section of a more inclusive overall subsea production system functional requirements specification.

Note: A single document may be used to cover multiple subsea chemical injection sub-systems associated with a single development.

- b. The SCIS functional requirements specification is intended to serve two primary functions:
 1. Provide a single repository or route-map for all relevant input design data.
 2. Contain (or reference a project specific document containing) production chemical data for all chemicals used, previously used or proposed to be used in the system.
- c. The SCIS functional requirements specification should, as a minimum, contain or reference the following SCIS pertinent information:
 1. Field geophysical data.
 2. Field process data (Including downhole data where appropriate).
 3. Flow assurance requirements for field life.
 4. Generic production chemical design input data.
 5. Production chemistry requirements.
 6. Specific/current production chemical specifications.
 7. Acceptable materials list and system materials map.
 8. System availability/redundancy/fault tolerance requirements.
 9. Selected SCIS field architectures.
 10. Applicable piping codes and standards.
 11. Pertinent SCIS detailed design requirements.
 12. Qualification, manufacturing and test requirements.
 13. Installation and commissioning requirements.
 14. Equipment storage requirements.
- d. Field geophysical data should define:
 1. All applicable water depths (i.e., platform and remote subsea equipment).
 2. Geographical locations of platforms and remote wells.



3. Key chemical injection system transportation conduit(s) paths and routes e.g., length(s) and demarcations of risers, umbilicals, pipelines, flying leads, etc.
4. Applicable surface operational temperature ranges (including storage, testing, and operational temperatures).
5. Applicable subsea operational temperature ranges.

A bulk of an SCIS is located subsea. Hence subsea environmental data, particularly subsea operational temperatures, have a significant influence of the physical properties of the injected chemical and overall system performance.

e. Field process data should define:

1. Process injection point flowing absolute pressure(s) and injection point shut-in absolute pressure(s) both in terms of peak values and life-of-field time dependent predictions.

2. Process fluid operational temperature ranges.

In normal circumstances the local process temperature(s) do not significantly affect the behaviour of the upstream SCIS.

3. Process fluid compositional characteristics (e.g., specific gravities, gas/oil/water ratio's, etc.).

Although not normally relevant to subsea (non-downhole) SCIS applications, it is recommended that this data be included for completeness.

f. If downhole chemical injection is required then downhole process data should define:

1. Applicable downhole injection point true vertical depths and tubing run lengths.
2. Process fluid composition including effective specific gravities at both standard conditions, injection point flowing pressure and injection point shut-in pressure.
3. Downhole injection point flowing absolute pressure(s) and downhole injection point shut-in absolute pressure(s) both in terms of peak values and life-of-field time dependent predictions.
4. Downhole operational temperature ranges.
5. All potential changes in process fluid composition along the downhole tubing length.

This data will have a significant localised influence of the physical properties (viscosity) of the injected chemical and hence, in view of potentially long lengths of downhole tubing, overall system performance.

g. Flow assurance requirements should include:

1. Why is a chemical required to be injected?

Each flow assurance issue requiring chemical injection remediation shall be described. The adverse implications of not achieving such remediation should also be described.

2. What is to be injected?

If known, the actual chemical shall be defined. If the actual chemical remains unknown, the generic production chemical type plus a defined "range" of potential candidate chemicals shall be defined.

3. Where is it to be injected?

Define required injection points in the subsea infrastructure.

4. How much is to be injected?



Define individual injection rates.

Define potential variations in injection rates that are envisaged as the field matures.

5. How often is it to be injected?

Define if continuous or batch injection is required at each injection point (this effectively defines whether simultaneous distributed chemical injection is required).

Define potential variations in injection frequencies that are envisaged as the field matures.

6. At what pressure is it to be injected?

Define the required maximum and minimum injection pressures and, further, the MWP.

7. What operating conditions will it be subjected to?

Production chemicals should be suitably qualified to meet the stability requirements associated with minimum subsea system temperature and pressures to maximum operating subsea temperatures (normally max well flowing temperatures).

h. Generic production chemical design input data should define:

1. A “defined” range of generic chemical physical properties that should be used as input to the SCIS design process.
2. The SCIS system should then be designed to provide acceptable system functional performance across this data range.
3. It is anticipated that, at an early stage in the SCIS project lifecycle, a specific production chemical will not have been identified and hence SCIS system design should be based on assumed chemical properties.
4. Consequently, an SCIS should offer a robust design solution that will allow acceptable operation over a “range” of alternative chemicals with differing physical properties.
5. Generic chemical physical properties should be “reasonable and realistic” values of:
 - a) Specific gravity range (plus significant pressure/temperature relationships).
 - b) Dynamic viscosity range (plus significant pressure/temperature relationships).
 - c) Bulk modulus range (plus significant pressure/temperature relationships).
6. As the above data covers multiple variables, a number of individual “theoretical property data sets” should be developed and defined.
7. Each theoretical data set should define a specific permutation of physical properties (i.e., an individual “set” of SG, viscosity and BM values) that together cover the extreme range of actual fluid physical properties that may be experienced throughout the life of field.
8. Theoretical chemical data sets should be selected with care – The simplistic definition of an unrealistic data set combining all extreme physical properties may have significant effects on the overall SCIS system design. It is recommended that a historical survey of existing chemicals be used to define “realistic” data sets that together will define an acceptable property range.

i. Specific/current production chemical specifications (when known) should include:

1. Production chemical name.
2. Production chemical health and safety information.
3. Specific gravity (plus significant pressure/temperatures relationships).



4. Bulk modulus (plus significant pressure/temperatures relationships).
5. Dynamic viscosity (plus significant pressure/temperatures relationships).
6. A blend of multiple individual chemicals should be treated as an individual unique chemical requiring the definition of a full data set of chemical physical properties.
Estimating or interpolating a chemical blend's physical properties from constituent properties without specific testing of the blend is not recommended.
- j. The acceptable materials list and system materials map, developed over the MPcp phases, should comprise:
 1. An acceptable materials list defining chemically wetted materials that may be used in each SCIS sub-system.
 2. A system materials map identifying the type, grade and location of all chemically wetted materials actually present in all SCIS sub-systems:
These are live documents that will develop and be accurately maintained over the project lifecycle
 3. Initially the specific chemical vendor(s) should be responsible for providing an acceptable material list(s) that defines the engineering materials that have previously been demonstrated to be fully compatible with the specific chemical.
 4. Any compatibility limitations (e.g., temperature limits, adverse material combination limitations, etc.) should also be defined.
 5. The chemical vendor(s) should also nominate preferred material(s) with evidence of their compatibilities with the chemical(s) over the project's operating environment (pressures, temperatures, chemical concentrations and chemical purity).
 6. This data should be used as design input for the initial vetting of materials proposed for use in all SCIS transportation conduits and all other relevant SCIS surface and subsea equipment items.
 7. The acceptable material list(s) and materials map(s) should then be developed and maintained throughout the project lifecycle by the BP project team and/or SCIS responsible contractor.
 8. Each SCIS equipment vendor should be responsible for providing detailed mapping of all chemically wetted materials present in their supplied equipment.
 9. This information should be collated into the materials map(s) and any new materials identified for potential inclusion in the acceptable materials list(s).
 10. New materials should only be added to the acceptable material list(s) following acceptance of compatibility testing results by BP materials specialists.
 11. An agreed material compatibility test programme should be established and accepted by both BP and the production chemical vendor.
- k. SCIS reliability and maintainability goals and requirements, in accordance with GP 78-03, should initially be defined by the BP project team during Appraise and then updated as the project evolves.
- l. These goals (normally desired reliability and maintainability (R&M) performance criteria that are not contractual requirements) and requirements (R&M performance criteria that are contractual requirements) should include but not be limited to:
 1. SCIS availability goals and requirements – The required minimum theoretical up-time that the SCIS should exhibit over a required time period.
Availability is the most commercially relevant reliability parameter and is often the best indicator of overall SCIS performance.



2. SCIS reliability goals and requirements – The theoretical probability that the SCIS will perform its required function(s) without failure for a required time period.
Using high reliability components can result in a system with high availability. Individual component reliability is of paramount importance for key subsea items that have either long repair times or are, effectively, “non-retrievable”.
3. SCIS maintainability goals and requirements – The probability that failed components can be repaired and/or replaced within a required time period.
Designing a highly maintainable system that allows quick and easy component repair and/or replacement can also result in a system with high availability. Good maintainability is essential for complex individual subsea components that have relatively low reliability.
4. Key input data to allow definition of the above goals & requirements also includes:
 - a) How important is each individual chemical injection capability to ongoing individual well and/or overall system production?
 - b) How long can each individual injection capability be absent?
 - c) What variations in chemical dosage rates can be accepted?
5. The definition of the R&M goals and requirements will allow the following system architectural layout decisions to be taken:
 - a) The levels of active redundancy required.
Normally exemplified by duplicated components, all operating, the survival of one component ensures continued system operation (typically topsides pump sets, etc.).
 - b) Levels of standby redundancy required.
Normally exemplified by duplicated components, only one of which is operating, the failure of one component requires an action to bring the redundant component on-line to recover system operation (typically spare umbilical cores, alternative injection points, standby AFCV's or PFCV', etc.).
 - c) Levels of equipment reliabilities required.
A potential alternative to redundancy is the provision of very reliable (and normally very simple) components that, by the nature of their design, offer high individual reliability and hence availability.
 - d) Levels of individual component maintainability required.
Normally exemplified by components that can be quickly repaired and/or replaced within an acceptably short timescale.
6. This output should be generated early in the project's Appraise phase to provide input to further define system architecture, layers of redundancy and component retrievability.
7. Reference shall be made to GP 78-04 for further detailed information on this subject.
- m. Selected SCIS field architectures shall be defined and documented:
 1. Reference should be made to Annex B for architecture selection guidelines.
 2. The definition of an acceptable SCIS architecture will require a multi-disciplinary interactive approach to combine the flow assurance requirements defined above with the required reliability/availability targets.
It is anticipated that this activity will require the combined skills of a flow assurance specialist, a reliability/availability specialist, a subsea equipment specialist and a chemical system hydraulic analyst.



3. The SCIS sub-system architecture(s) selection process should be documented.
 4. The outline specifications for key system components (i.e., surface pump sets, surface flow control valves, subsea flow control valves, etc.) should be documented.
 5. This information should be used as input to subsequent design activities to define detailed specifications for topsides pumping systems, acceptable subsea flow control devices and required conduit sizes.
- n. Applicable piping codes and standards shall be defined and documented:
1. Applicable pressure piping codes and standards for all constituent parts of the SCIS.
 2. Location of code breaks (where relevant). Code breaks should normally be located at natural equipment interface breaks within the SCIS.

The primary implication of different applicable piping design codes is that associated with the required proof pressure test criteria. Locating a code break within one discrete deliverable assembly may have significant adverse implications for proof pressure testing of that assembly. A common experience is that a common proof pressure cannot be identified for differing sections of internal piping requiring that two independent tests are performed on partially disassembled equipment followed by a third "leak test" on the reconnected lines.

- o. Pertinent SCIS detailed design requirements shall be defined and documented:
1. Pertinent design requirements applicable to the actual system(s) should be documented.
 2. It is anticipated that these requirements will be a selected sub-set of the complete SCIS design guidelines contained in later sections of this GP and should, therefore, influence bid tendering and/or contract award.
 3. This section should be revisited by both BP and the successful equipment vendor and updated as necessary prior to or during the project execution phase.
- p. Qualification, manufacturing and test requirements shall be defined and documented:
1. Pertinent qualification, manufacturing and testing requirements applicable to the delivery of the actual system.
 2. For required qualification activities, it is anticipated that these requirements will cross reference GP 78-06.

This data may influence bid tendering and/or contract award.

- q. Installation and commissioning requirements shall be defined and documented:
- r. Equipment storage requirements shall be defined and documented:

1. Applicable storage and test environments that the delivered equipment may experience prior to subsea installation.
2. Storage fluid(s) to be used for all items of SCIS equipment when the final service chemical cannot be used.
3. Reliance should not be placed on subsea flushing operations to remove all traces of storage fluid from the system.

In many instances storage and testing environmental conditions are more extreme than service conditions.

In many instances adverse reactions have occurred between the temporary storage and installation fluids with both SCIS equipment materials and/or resulting mixtures with production chemicals. This risk is particularly high for the SCIS umbilicals, all



interconnecting chemical flying leads and short lengths of tubing incorporated in various items of subsea equipment.

5.3. SCIS system design calculation package

- a. A system performance design calculation package should be developed and maintained for each SCIS. The package may include (but not be limited to) the following:
 1. SCIS system chemical flow performance analysis.
 2. SCIS reliability, availability and maintainability (RAM) analysis.
 3. SCIS failure modes and effects analysis (FMECA).
- b. Coherent units of pressure should be used throughout the SCIS system design calculation package and particularly in the chemical flow performance analysis.
- c. Pressure units should clearly and unambiguously define if they are referring to a pressure level (bara or psia) or a pressure difference (bar or psi).
- d. The SI recognised units of bara and bar are normally preferred. It is recognised that psi and psia remain the US customary units of relative pressure difference and absolute pressure levels respectively. Where these units are the preferred local measuring system they may be used in place of the recommended bara and bar SI recognised units.
- e. Note that a mixture of imperial and SI recognised units within a single project should be strongly discouraged.
- f. The absolute pressure unit “bara” or “psia” (i.e., representing a pressure level referenced to vacuum) shall be used when specific pressure levels at various points in the system require to be defined.
- g. The relative pressure unit “bar” or “psi” shall be used when a difference between two pressure levels requires to be defined.
- h. Pressures measured in “gauge” units (i.e., barg or psig) are strongly discouraged as there are significant variations in ambient pressures throughout an SCIS (particularly downhole) and these units can potentially be ambiguous.
- i. An initial system chemical flow performance analysis should be developed early in the project life cycle to allow initial transportation conduit line sizing. This analysis should be of sufficient accuracy to allow conduit sizing to be performed with confidence.
- j. A steady-state quasi-static (i.e., equilibrium conditions) analysis will be acceptable for this model. This, hopefully, will reduce the requirement for complex software which would otherwise be necessary should a transient analysis be required.
- k. The initial system chemical flow performance analysis should provide the following:
 1. An indication of SCIS system chemical injection performance using extreme envelope (design limit) chemical property data-sets. This should then enable preliminary assessment of equipment sizing (e.g., pump flowrates, system design pressures, conduit sizes, completion equipment settings, etc.).
 2. Predicted “as-built” SCIS system performance using actual chemical properties and flow conduit sizing and configuration. Operational feedback should be used to refine the model, as necessary, to improve performance accuracy to acceptable levels.
- l. An “as-built” system chemical flow performance analysis should be developed from the initial analysis during execute which should identify, model and analyse:
 1. “As-built” system architecture(s).
 2. Confirmed injection point locations.
 3. “As-built” CIU pump sizes and bulk storage provision.



4. Control and instrumentation set-points and alarms levels.
 5. Definition of “as-built” transportation conduit sizes.
 6. Definition of “as-built” surface and subsea flow control valve performance characteristics.
 7. Identification of significant local flow restrictions (e.g., flow coefficients, C_v 's).
 8. Identification of SCIS check valve cracking pressure settings.
 9. System performance with “as-used” production chemical.
 10. Minimum injection flow rate calculations.
 11. Maximum simultaneous injection flow rate calculations.
- m. The “as-built” system chemical flow performance analysis should provide the following:
1. An analytical tool to facilitate day-to-day operational SCIS equipment reconfiguration and/or adjustment to allow for management of any required changes in chemical injection regimes.
Particularly important for distributed type ‘B’ or type ‘D’ systems where subsea flow control valve adjustment may be problematic without this tool.
 2. Allow predicted system performance with any potential future chemical to be defined prior to its introduction into the system.
The results of this analysis may enable the production chemical vendors to further develop their chemical’s effectiveness and/or physical properties using a positive feedback loop.
- n. Accurate analysis of predicted chemical flows through an SCIS is dependent on an unambiguous understanding of the driving pressures and hydraulic heads present throughout the system. A coherent method of defining pressures should therefore be used in the system chemical flow performance analysis.
- o. The system reliability, availability and maintainability (RAM) analysis shall define and quantify the SCIS theoretical R&M performance and contrast this with the R&M goals and requirements identified in the SCIS functional requirements specification (reference 5.2.k):
1. Required system R&M goals and requirements.
 2. Consider the impact of the SCIS on total subsea production system performance.
 3. Define levels of equipment reliability, redundancy and/or maintainability required to achieve R&M targets.
 4. Identify pertinent “lessons learnt” input from previous projects.
 5. Identify SCIS perceived risk areas.
- p. A system failure modes and effects analysis (FMECA) analysis should be performed if identified in the SCIS reliability plan (generated as part of the project’s risk and reliability strategy, GP 78-03). This analysis should:
1. Identify all possible SCIS single point failure mode scenarios.
 2. Identify all possible causes of these failures.
 3. Identify all possible effects of these failures.
 4. Identify all possible means of detecting these failures.
 5. Identify probabilities of these failures.
 6. Identify corrective actions to be followed.



- q. The FMECA should be performed, if required, at an early stage in the project life-cycle to ensure that possible design improvements (where identified) can be incorporated in the system design.

6. Detailed SCIS design guidelines

6.1. Introduction

- a. During the Appraise, Select, and Define stages of a project, relevant guidelines from this section of this GP should be incorporated into the SCIS system functional specification to be used for bid tendering and/or contract award purposes.
- b. Where relevant the design guidelines should be presented in relevant SCIS architecture specific individual sections for ease of use.
- c. Design guidelines should be reviewed for applicability prior to incorporation into the SCIS system functional specification.

6.2. Generic SCIS design guidelines

6.2.1. Applicability

This section defines functional requirements that are normally applicable to all SCIS architectural types and applications.

6.2.2. Environmental issues

- a. The use of production chemicals and their potential discharge into the environment shall be in compliance with applicable local environmental legislation.
- b. In the absence of applicable local environmental legislation, guidance should be sought from the BP environmental department to allow definition of appropriate environmental design criteria.
- c. As a guiding principle, the SCIS should be designed to minimise the discharge of chemicals into the environment.

6.2.3. Redundancy, fault tolerance and fault mitigation

- a. The required levels of redundancy, fault tolerance and fault mitigation are dependant on the required SCIS availability target, the reliabilities of all equipment used and the anticipated repair times.
- b. Generally the following guidelines (c to i) are applicable (note that these guidelines may also be specifically addressed elsewhere in this document).
- c. A re-configurable multi-purpose spare chemical core in the transportation conduit should be considered.
- d. Potential adverse interactions between chemicals and storage fluids should always be considered prior to changing or mixing any fluids in any transportation conduit.
- e. The effects of potential single point failures on system operation should be considered. Active or standby redundancy in flowpaths and/or key items of subsea equipment should be considered for critical chemical injection services.
- f. Potential intervention costs and production system downtime associated with standby redundancy philosophies should be considered.
- g. Critical non-redundant subsea chemical distribution paths should comprise fully welded hard pipe conduits interconnected with metal-seal couplings.



- h. Flexible thermoplastic hoses terminated with crimp-style end-fittings and couplings relying on non-metallic sealing techniques should not be considered suitable for critical non-redundant applications.
- i. The means of providing alternative (multiple) chemical flow path(s) into the process flow should be considered for critical applications.
- j. An alternative chemical injection flowpath into the process flow may not offer full redundant functionality, but should allow continued production until primary system operation can be restored.
- k. The predicted failure modes of SCIS subsea components should be assessed as part of the system FMECA (reference 5.3) to establish predicted detrimental effects on the SCIS and to identify possible mitigation.
- l. Failed parts in a redundant equipment configuration should be individually retrievable whilst maintaining redundant system operation. ROV retrieval techniques are preferred.
- m. Active redundant SCIS subsea instrumentation should be considered for critical applications. In general subsea block-and-bleed instrument manifolds are not preferred.

Subsea block-and-bleed manifolds can reduce overall instrument reliability and may be subject to internal blockages.

6.2.4. Materials and material compatibility

- a. Reference is made to the requirement for the development and maintenance of project specific acceptable materials lists and system materials maps defined in 5.2.
- b. Materials of construction for subsea equipment shall be selected in accordance with principles described in GP 36-20 and EEMUA 194.
- c. Non-metallic materials should be selected and qualified in accordance with principles described in GN 36-003, GN 36-015, and GN 36-007.
- d. Materials used in downhole applications shall be selected in accordance with principles described in GN 36-004.
- e. Selection of the optimum materials should not be compromised.

Selection of the materials is critical in recognising the potential impact of SCIS failure to deliver chemicals - to maintain both the process integrity, (formation of hydrates, wax, scales, etc.) and; - the loss of mechanical integrity (corrosion) of the subsea system.

- f. The number and permutations of different chemically-wetted materials should be minimised.
- g. CRAs should be used where possible.
- h. The choice of sintered material binding alloys should be carefully considered.
- i. The following chemically-wetted materials should be avoided:
 - 1. Carbon steels (except for supply pipelines carrying bulk non-corrosive chemicals such as glycol or methanol).
 - 2. Martensitic or precipitation hardened stainless steels (e.g., UNS S44004 “440-C” or UNS S17400 “17-4PH”).
 - 3. Plated materials (e.g., chromium, electroless nickel, zinc and cadmium plating).
 - 4. Coatings.
 - 5. Aluminium.



- 6. “Yellow metals” (i.e., brass and bronze alloys, aluminium bronze, phosphor bronze, copper, copper nickel alloys).
- j. Where carbon steel pipelines are used, potential particulate contamination issues (progressive liberation of mill-scale, etc.) should be considered particularly where downstream filters and/or downstream contamination intolerant flow control valves are present.
- k. Metal-to-metal sealing technologies should be used where possible.
- l. Elastomeric seals should be minimised (preference should be given to metal-to-metal sealing technologies). PEEK polymer materials (polyetheretherketones) are preferred for non-metallic back-up seal materials for deepwater or high pressure applications (PEEK typically exhibits excellent compatibility with most chemicals).
- m. Alternatively spring- or pressure energised PTFE seals may be considered. Where elastomers are considered necessary, perfluoroelastomers such as Chemraz®, Kalrez®, etc. are preferred.
- n. Where metal-to-metal seals are used for methanol service, an additional non-metallic seal should be considered as a back-up.

This is due to potential problems resulting from cavitation and flow-induced material degradation (erosion wear).

- o. Special precautions should be taken when dual seals are utilized in any pressure-containing design. The interstices between the seals may remain at atmospheric pressure with the result that both seals will potentially accommodate both internal chemical system pressures and also external ambient seawater pressures.
- p. Unidirectional seals should be used with caution. In addition, the assembly of dual seals with trapped fluid within the interstices can also lead to the generation of extreme internal pressures causing both immediate seal damage plus also the possibility of inadequately mated sealing surfaces (i.e., unintentional extrusion gaps formed between mating faces).
- q. Permeation of fluids through polymer hose liners/materials (typically experienced with low-mass chemical constituents) should be considered.
- r. Steel-tube umbilicals (normally utilizing superduplex stainless steel individual cores) are preferred over thermoplastic hose umbilicals for chemical injection systems. Steel-tube flying leads (jumpers) should also be considered for high integrity/high reliability applications.

This approach obviates methanol permeation issues through thermoplastic hose liners, utilises umbilical cores with inherent negative differential pressure collapse resistance and allows an “all-welded connection” philosophy to be used that minimizes (or avoids) active seals.

- s. Where thermoplastic hoses are used in subsea equipment (e.g., umbilicals, flying leads, hook-up connections, etc.), the adverse effects of subsea hyperbaric pressure on hose cross-section stability should be considered.
- t. Anti-collapse hoses should be used where any potential for hose collapse is identified.

6.2.5. Accommodating/limiting diversity in production chemical physical properties

- a. During a project’s life-cycle, emphasis should be placed in two areas:
 - 1. Designing the SCIS to be tolerant of a wide range of chemical physical properties - The SCIS design should be tolerant to the impact of changes of the chemical physical properties within the vendor’s specified range, which could affect performance criteria such as injection rates.



2. Encouraging the vendors' of production chemicals to limit diversity in chemical physical properties.

The performances of both an overall SCIS and individual flow control devices are appreciably influenced by the actual production chemical's physical properties (primarily viscosity) and the required dosage rates. Replacement of production chemicals during the life of the field may introduce significant changes in these parameters which may adversely affect system operation.

6.2.6. Identification of MWP

- a. The SCIS MWP should allow the system to develop a suitable pressure head to flow the maximum required chemical injection flowrate through all intervening transportation conduits and components into the highest predicted process pressure.
- b. Conversely, the SCIS should not have the potential, in normal operation, to over-pressurise the receiving equipment when the process flow is shut-in.
- c. The identification of a suitable MWP is an iterative process that should consider numerous conflicting input parameters.
- d. The following clauses define the maximum permissible SCIS MWP depending upon the chemical injection location. The minimum acceptable SCIS MWP should be established during the system chemical flow analysis and considered an upper limit.

- a) Subsea chemical injection systems injecting into the subsea tree upstream of the production wing valve shall have an SCIS MWP not exceeding the tree rated working pressure.

Limiting the SCIS MWP to tree rated pressure ensures that the SCIS cannot over-pressurise the tree (upstream of a closed production wing valve) in normal operation.

- b) Subsea chemical injection systems injecting into manifold piping, subsea pipelines/flowlines or into an free downstream of the production wing valve shall have an SCIS MWP not exceeding the lowest rated component between the PWV and the normal downstream production flow isolation valve.

Limiting the SCIS MWP to the lowest rated receiving subsea process equipment ensures that the SCIS cannot over-pressurise the subsea process equipment in normal operation.

- e. The possibility of inadvertently over-pressurising downstream process equipment with an SCIS injecting upstream of the production wing valve should be considered.
- f. Inadvertent over-pressurisation of process equipment downstream of the PWV should normally be prevented by operational procedures and/or alarms.
- g. This event should be defined as a short duration abnormal over-pressure excursion that can be accommodated in the design code safety margin.

6.2.7. Individual design pressure of SCIS components covered by ISO 13628 part 6 (subsea production control systems)

- a. ISO 13628-6 is the ISO standard within this series generally applicable to subsea chemical injection systems. It is applicable to the CIU and other subsea components not specifically covered by one of the further ISO standards in the same series.
- b. Relevant SCIS components specifically covered by ISO 13628 part 6 shall have an individual design pressure equal to or exceeding the topsides system pressure safety valve (PSV) setting.



The ISO 13628 part 6 design pressure (i.e., system pressure safety relieve valve setting) is normally 10% above the MWP.

6.2.8. Individual design pressure of SCIS components covered by ISO 13628 part 5 (subsea umbilicals)

- a. ISO 13628-5 is the standard specifically covering the subsea umbilical(s).
- b. Umbilical cores and relevant SCIS components covered by ISO 13628 part 5 shall have an individual design pressure equal to or exceeding the umbilical “design working pressure” which shall itself equal or exceed the MWP.

The MWP is defined by the normal SCIS pressure controlling device (CIU pressure regulator and/or pump control pressure switch settings).

6.2.9. Individual design pressure of SCIS components covered by ISO 13628 part 4 (subsea wellhead and tree equipment)

- a. ISO 13628-4 is the standard specifically covering the subsea wellhead and tree equipment.
- b. Relevant SCIS components on the tree shall have an individual design pressure equal to or exceeding the tree rated working pressure which shall itself equal or exceed the MWP.

The tree rated working pressure is normally a standard rating sufficiently above the WHSIP so as to allow well kill, stimulation, and/or injection operation.

6.2.10. Definition of chemical supply pipeline MAOP

- a. MAOP shall be relevant only to chemical supply flowlines and pipelines covered by the project selected “geographical location applicable” subsea piping code.
- b. Such pipelines shall have a MAOP equal to or exceeding the MWP.

6.2.11. Preferred locations of subsea injection points

- a. The preferred locations of subsea chemical injection points should be selected based on input from BP process, flow assurance, and specific equipment engineers.
- b. The potential for overall system availability improvements resulting from the use of redundant chemical injection points should be considered where chemical injection services are considered critical to SPS operation.

The injection point location normally defines the maximum permissible MWP that avoids over-pressurisation of the receiving equipment as defined in previous clauses.

6.2.12. Avoidance of multiple conflicting active flow control devices in a single system

- a. The flow of chemical at each subsea or downhole chemical injection point should be directly controlled by only one active flow control device in the relevant SCIS sub-system.
- b. In-series active flow control devices should be avoided.

Note that a surface positive displacement pump (without an active pressure maintaining spill-back valve) is considered to be an active flow control device.

Multiple active flow control devices conflict and normally produce unstable, unpredictable system operation.

6.2.13. Segregation between subsea injection points

- a. Individual, segregated, injection points should be provided for individual production chemicals injecting into the subsea process flow.



- b. Commingling manifolds immediately upstream of a single injection point should not be used.

The provision of shared common manifolds upstream of a single injection point, where multiple chemicals can be sequentially or concurrently injected into the process stream, is considered bad practice. Uncontrolled mixes of highly concentrated chemicals may adversely interact.

6.2.14. Chemical cocktails

- a. In general the use of chemical cocktail blends (i.e., the deliberate mixing of two or more individual production chemicals) to reduce the number of individual surface pumps, umbilical cores, subsea flow control valves, and subsea injection points) should be viewed with caution.
- b. Any chemical cocktail blend developed should be treated as an individual unique chemical requiring full material compatibility testing, definition of a full set of chemical physical properties, and full SCIS hydraulic modelling.
- c. Chemical blending should be performed by the chemical vendors prior to delivery in order to obtain a consistent and homogeneous blend.
- d. Chemical cocktail blends should only be used if a clear technical and economic case can be made for the decision including an assessment of potential future operational constraints introduced by such a decision.
- e. The potential future requirement to replace one or more production chemicals for technical, economic, or environmental reasons should be considered.

6.2.15. Subsea chemical injection non-return check valve cracking pressure

- a. The subsea chemical injection non-return valve cracking pressure should be set at a nominal 5 bar value.
- b. A relatively high cracking pressure should be used to ensure that the internal poppet is firmly re-seated each time after operation.

6.2.16. System chemical cleanliness requirements

Chemical cleanliness requirements for an SCIS are dependent on the presence, or otherwise, of potentially contamination intolerant components in the system and hence are dependent upon the system architecture. Reference should therefore be made to the individual architecture design guidelines for specific cleanliness recommendations.

6.2.17. Subsea filtration

- a. Subsea filters should be fitted upstream of active or passive flow control valves and where DCIVs are used. These should be in addition to any “last-chance” filter/screens integral to the flow control device(s).
- b. Each filter element and housing shall, as a minimum, be sized to accommodate the maximum anticipated chemical flow contamination over a two year period.
- c. The filter media should be selected with an absolute filter micron rating suitable for the required system cleanliness and with a maximized “beta ratio”.
- d. The filter media should not have an absolute filter micron rating coarser (less fine) than that provided by the CIV vendor last chance filter.
- e. The filter element should feature a high differential pressure capability to eliminate the probability of element break-up in service.
- f. Subsea filters should be fitted with bypass facilities to allow continued operation (in extreme conditions) with a blocked element.



- g. A means of detecting contamination build-up in filters and/or a bypass indication should be provided.
- h. Subsea filters should be supplied in redundant configurations such that a contaminated filter may be taken off-line (by ROV) and flow redirected to a stand-by filter with the minimum of disruption to the SCIS.
- i. Individual subsea filters should be designed for ROV recovery and replacement without affecting the redundant filter. A purely “diver-only” solution is not a preferred option.
- j. Where possible it is recommended that consideration should be made for post-installation flushing of the complete SCIS distribution system prior to commissioning.
- k. The flushing loop should preferably include the subsea filters which should, subsequently, be replaced.

This could take the form of a temporary subsea cross-over plate between two independent chemical injection umbilical cores. A circulation route back to a surface flushing unit allows displacement of the umbilical storage fluid plus the ability for a detailed examination of the displaced fluid to determine the effectiveness of the flushing/displacement operation. Note that turbulent flushing would normally be extremely unlikely owing to typically long umbilical lengths.

6.2.18. Surface CIU design guidelines

6.2.18.1. General

A surface CIU should be designed in accordance with ISO 13628, part 6 and as modified in Annex A of this GP.

6.2.18.2. SCIS system PSV setting

The SCIS PSV installed to provide an absolute pressure limit on the CIU chemical injection pump output shall be set at 10% above the MWP.

The PSV setting defines the ISO 13628, part 6 SCIS system design pressure. The 10% margin allows the PSV to completely reset following an abnormal pressure excursion.

6.2.18.3. CIU component design pressures

Internal CIU pressure containing components shall have individual design pressures equal to or in excess of the SCIS PSV setting.

6.2.18.4. CIU output pressure during normal operation

The CIU output pressure in normal operation shall be limited to the MWP by a suitable pressure-controlling device (pressure regulator, pump spill-back valve or pump control instrumentation).

6.2.18.5. CIU chemical cleanliness design requirements

- a. For chemical injection systems featuring surface active flow control valves, subsea active flow control valves, highly restrictive subsea passive flow control valves and/or downhole injection capabilities, it is recommended that the CIU be considered analogous to an SPCS HPU and similar techniques should be used to achieve and maintain chemical cleanliness.
- b. The central philosophy is that the CIU should be capable of cleaning up all chemicals to a sufficient cleanliness level before injection into the subsea transportation conduit.
- c. The CIU cleanliness design philosophy should include:



1. Provision of separate clean (ready-for-use) and dirty (clean-up) reservoirs in the CIU, complete with offline circulation/clean-up pumps and filters.
2. Routing all chemical returns from downstream of the CIU into the “clean-up” reservoir.
3. Provision of independent filtering of a CIU constant pressure pump “spill-back” line returning to the “ready-for-use” reservoir.
4. Provision of permanently installed purpose-built chemical transfer facilities between chemical transportation containers and the CIU (or bulk storage facility).

6.2.18.6. CIU pump requirements – positive displacement pump set

- a. A topside positive displacement pump set is used to:
 1. Provide a pre-determined constant chemical flowrate into the transportation conduit (i.e. perform as an AFCV).
Note: A positive displacement pump can also be part of a constant pressure pump set in conjunction with a pressure limiting device (reference 6.2.18.7).
 2. Pressurise the chemical.
The actual pressurisation level will be a response to the overall system flow restrictions and process pressure level(s).
- b. In all applications the pump set should have a maximum design flowrate capacity of 125% of the totalised maximum required injection flowrates into all parallel injection points at the MWP based upon the “worst case theoretical property data set” (reference 5.2).
The “worst case theoretical property data set” will normally be that with the highest viscosity.
- c. The pump set should have a minimum design flowrate capacity (i.e., turn-down capability) to achieve 90% of the minimum required injection flowrate.
- d. The pump set should be tripped and alarmed on high discharge pressure (using a pressure switch or pressure transmitter) should the discharge pressure exceed the MWP.
- e. The pump set shall be fitted with a system PSV normally set at 10% above MWP in accordance with ISO 13628 part 6.

6.2.18.7. CIU pump requirements – constant pressure pump set

- a. A topside constant pressure pump set is used to:
 1. Pressurise the SCIS to a constant pre-determined value.
The actual pressurisation level will be control by local instrumentation.
 2. Provide a variable chemical flowrate into the transportation conduit.
The actual flowrate will be in response to a fluid demand on the system.
- b. In all applications the pump set should be designed with a suitable maximum flowrate that can charge-up the SCIS transportation conduit(s) to the required operating pressure within the project specified time period.
A topside constant pressure pump set is used to pressurise the chemical to a pre-determined constant pressure value. A constant pressure pump set will normally feature a positive displacement pump in conjunction with a spill-back valve (back-pressure regulator).
- c. The pump set should also have the ability to operate at a nominal flowrate capacity (i.e., turn-down) of 125% of the totalised maximum required injection flowrates into all parallel



injection points at the MWP based upon the “worst case theoretical property data set” (reference Section 5.2).

This will represent the normal operating setting under full load conditions. The “worst case theoretical property data set” will normally be that with the highest viscosity.

- d. To assist system operability the pump set should also have the ability to operate at a minimum design flowrate capacity (i.e., turn-down) of 90% of the minimum required injection flowrate.
Although not strictly required, this functionality will assist system operability by minimising the excess fluid “spilled-back” in non-peak operating conditions.
- e. The pump set “spill-back” system (back pressure regulator), used to provide the constant output pressure, should be capable of providing a maximum constant pressure equal to the MWP.
- f. The pump set “spill-back” system (back pressure regulator), used to provide the constant output pressure, should be capable of providing a minimum constant pressure equal to the calculated minimum operating pressure established as part of the system chemical flow analysis.
- g. The pump set shall be stopped and alarmed on high discharge pressure (using a pressure switch or pressure transmitter) should the CIU discharge pressure exceed the MWP.
- h. The pump set shall be fitted with a system PSV normally set at 10% above MWP in accordance with ISO 13628 part 6. This should not be used as the “spill-back” pressure controlling device.
- i. The pump set actual flowrate setting should always be set in excess of the sum total of all downstream AFCV’s in concurrent operation in the system.

Any AFCV will become “non-functional” if the actual supplied flowrate is below the AFCV flowrate setting. This will be characterised by the AFCV behaving as a simple fixed flow restriction and the upstream pressure may not build-up to reach the nominal spill-back pressure.

6.2.18.8. Establishing surface AFCV flow capacity requirements

- a. A surface AFCV can be used in type ‘A’ and type ‘B’ SCIS architectures in combination with a constant pressure pump set to provide the means of regulating the chemical flowrate into one or more transportation conduits.
- b. Each surface AFCV should normally have a maximum design flowrate capacity of 125% of the maximum required downstream injection flowrate at the MWP based upon the “worst case theoretical property data set” (reference 5.2).

The “worst case theoretical property data set” will normally be that with the highest viscosity property.

- c. A surface AFCV should have a minimum design flowrate capacity (i.e., turn-down capability) to 90% of the minimum required downstream injection flowrate based upon the “best case theoretical property data set” (reference 5.2).

The “best case theoretical property data set” will normally be that with the lowest viscosity property.

6.2.18.9. CIU output line flow measurement

- a. The chemical flowrate and totalised flow through each CIU output line should be measured using local CIU instrumentation and made available to the DCS for display.
- b. Local flowrate and totalised flow display can also be provided.

