

MANUAL

CHEMICAL INJECTION FACILITIES

DEP 31.01.10.10-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for the design of chemical injection systems for new or refurbished exploration and production facilities. It is based on the requirements for offshore and onshore production facilities.

This DEP will assist in the conceptual and detailed design of new projects, and is directed towards both the Principal's design team and the engineering design Contractor.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group or managed by a Group company.

This DEP is intended for use in exploration and production facilities. When DEPs are applied, a Management of Change (MOC) process should be implemented. This is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements 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 that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

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

The **Principal** is the party that 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, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 ABBREVIATIONS

IBC	Intermediate Bulk Containers
IRCD	Injection Rate Control Devices
NNM	Not Normally Manned
P&ID	Process and Instrumentation Diagram
MSDS	Materials Safety Data Sheet
VPRV	Vacuum Pressure Relief Valve

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (4) and (5).

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com.

Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards/DEP 31.01.10.10-Gen. folder. The DEP Administrator and DEP Author monitor these folders on a regular basis.

2. CHEMICAL INJECTION SYSTEM GOALS, DESCRIPTION AND DESIGN

2.1 SYSTEM GOALS

Permanently installed chemical injection facilities may be required for oil and gas production, water injection, efficient clean-up and the reduction of corrosion problems; see (Appendix 1).

The overall goals of the chemical injection system are:

- to store and deliver chemicals (load/unload containers) safely in the required quantity and quality;
- to accommodate changes in dosage rates and chemicals used;
- to satisfy the availability requirements of the facilities being served;
- to allow verification of the injection rate and, for critical applications, to generate an alarm if the injection rate goes outside preset limits.

The design and operation of the chemical injection facilities are an inherent part of the process management system. The chemical injection hardware should therefore be provided as described in this DEP, and appropriate operational procedures should be developed in order to ensure that the chemical injection goals are met. The selected chemicals and injection dose rates, procedures, operator training, and monitoring and inspection data should be analysed and the results fed back to optimise the chemical injection process.

Report EP 2000-5721 provides guidelines on corrosion control for inhibited systems and relevant extracts are summarised below. Similar principles apply to chemicals other than corrosion inhibitors.

In offshore operations, experience with chemical injection systems has varied from highly reliable to very poor with severe corrosion, and in extreme cases, corrosion failure of pipelines being experienced. Experience suggests that in actual field situations it is not necessarily the equipment design that is deficient, but the operations element has not been adequately addressed. The cost effectiveness of back up systems and automation should be considered during the design in order to reduce operational maintenance.

The achievement of high chemical efficiency is critically dependent on the people element, particularly during operation. A high level of availability will not be achieved unless there is adequate training and management, e.g., the setting of key performance indicators to be met. If systems are designed where there is potentially a conflict between a focus on production and a focus on achieving the required availability, the inhibition system could suffer.

The selection of chemical injection system hardware to achieve a specified availability shall consider a number of factors:

- For remote operating locations, the more sophisticated equipment required for high availabilities may be difficult to procure initially, and it may be difficult to get spare parts for maintenance;
- Operating levels vary by location. In some locations, manual monitoring of pump performance and injection rates is practicable, whereas in other locations the number of staff visiting a location has to be strictly limited, e.g., NNM platforms;
- Higher availability will result in a lower required system corrosion allowance, and an economic assessment of acceptable options should be carried out to determine the optimal design of chemical injection facilities.

2.2 SYSTEM DESCRIPTION

2.2.1 Storage, mixing, metering, dosing and calibration

At offshore locations, chemicals are generally transported in intermediate bulk containers (IBCs) and are subsequently transferred to bulk storage tanks. IBCs may also be used for storage at the facility or as direct replacement for the modular injection unit storage tank if the design permits. Smaller quantities may be transported in small portable tanks, barrels or drums.

At onshore locations, IBCs are increasingly replacing drums as transport containers because IBCs usually prove more economical, provided the handling capability is present. If required, the chemicals are then diluted and mixed. The chemical flow is metered before being manifolded to the injection pumps. The injection pumps dose the chemicals either continuously or intermittently into process or utility systems on the onshore facility / platform, or at nearby subsea developments. Calibration facilities are provided to measure the dosage sent to the individual injection points.

2.2.2 Facilities

At manned installations, the chemical bulk storage, mixing, metering, pumping and calibration facilities shall be located in a single integrated chemical injection package (hereafter referred to as the main chemical injection package) to ensure flexibility during field life. At offshore facilities, this package should be a two-level structure with the tanks located adjacent to the pumps to achieve efficient use of space and good access. The roof of the package should be used, if possible, as an IBC laydown area; see Figure 1. For additional layout requirements on offshore facilities, see (3.8). At onshore facilities, where more space is usually available, the layout may be different to accommodate alternative methods of filling.

If an injection duty requires large volumes (more than 10 m³) of storage (e.g. methanol injection), and the possibilities of interchanging chemicals and facilities are limited, then a dedicated (subsidiary) chemical injection package should be provided.

Subsea developments use the facilities of a nearby platform and so are supplied by pipeline (or umbilical) directly into the well stream or process facility.

For not normally manned (NNM) facilities or platforms, the required tanks and pumps should be minimised as far as reasonably practicable. Thus for chemical injection on NNM facilities or platforms, the use of pipelines (or umbilicals) from manned installations should be considered. Similarly, chemicals requiring dilution should be supplied to NNM facilities or platforms in diluted form, with any required mixing preferably being done onshore.

2.3 SYSTEM DESIGN

2.3.1 General

The optimum system design depends on a number of factors including the desired availability, degree of operator intervention and space available. Table 1 provides a guide to various design items according to different levels of availability, represented by the factor, **f**. For corrosion inhibitor application, as a guide, the frequency of operator involvement is also included in Table 1 to allow the injection system to be designed to facilitate the operator's efforts. A similar approach can be devised for other chemical applications.

Table 1 Criteria for Chemical Injection System Design to Meet a Specified System Availability (extracted from Report EP 2000-5721)

Item	Availability, f		
	Good (f = 0.95)	Excellent (f = 0.99)	Critical (f > 0.99)
Inhibitor demonstrated as suitable for the application	Required	Required	Required
Inhibitor injection pumps	Standard	High reliability	High reliability
Back up pumps	Not required	Required	Required
Check that pump is operating	Daily, manual check	Automated alarm	Automated alarm
Pump planned maintenance	Annual	Annual	May be required more often
Inhibitor tank levels	Daily manual check	Automated alarm	Automated alarm
Report on inhibitor used (or report on compliance with key performance indicators) to responsible corrosion engineer	Monthly	Weekly	Daily
Quarterly manual check on pump injection rate, calibration check on meters	Required	Required	Required
Low or no flow alarm (out of specification, differential pressure across a critical component, or inline flow meters)	Not required	Required	Required
Liquid samples for analysis of residual inhibitor levels and water chemistry	Monthly	Monthly	May be required more often
Corrosion monitoring system response	At least annual manual measurement	Online ER probes; response time 1 day to 7 days	Online fast response monitoring systems; response time 1 hour to 24 hours
Comprehensive review of uninhibited events	Desirable	Required	Required
Persistency taken into account	Not required	Not required	Required
Allowed days inhibitor system downtime per year	18	4	0 to 4
Shut in if inhibition system goes down for greater than the allowed period of time	Effectively never an issue	Possibly	Required
Identify operations technician with responsibility for the inhibition injection system	Required	Required	Required
Corrosion engineering involvement	Monthly review	Weekly review	Daily review
Key Performance Indicators set for operations technicians and corrosion engineers	Required	Required	Required

The following Sections of this DEP describe the variables to be evaluated in the selection of an optimum chemical injection system for an offshore installation.

A typical chemical injection P&ID is shown in Figure 2 for the storage and injection of undiluted chemicals for a system of good availability ($f = 0.95$).

Equipment shall be procured from Suppliers approved by the Principal and shall have a proven track record in similar service.

2.3.2 Design for chemical selection, duty and properties

Chemical injection facilities are required to be both accurate and flexible. Accuracy is required to ensure that the treatment is effective and cost-efficient and does not unnecessarily impact the environment. Flexibility is necessary because:

- a wide range of throughputs and/or process fluid properties occur during the life of a production facility which means that the chemical injection system must have a correspondingly large turn-up or turn-down capability. This could, for instance, necessitate the installation of 2 pumps to better accommodate the accuracies required over wide turn-down ratios;
- many chemical injection systems cannot be designed on the basis of one chemical being used throughout the life of the platform because availability, economics, policy or operational parameters may dictate changes in chemicals during field life.

Therefore, for any given chemical injection duty:

- the pump sizing and storage volume shall be suitable for each chemical which, during the conceptual design, is judged likely to be used in that duty;
- the full range of possible operational conditions, and not just the maximum flowrates, shall be considered and the equipment designed accordingly;
- material selection shall be compatible with the chemical(s) envisaged and also consider connections downstream of the injection module, e.g., umbilicals;
- the HSE properties of chemicals shall be considered in the light of any requirements for intrinsic safety in design. The Principal's discipline engineers and materials/chemicals specialists should select the chemicals used. This selection should give due consideration to minimising fire hazard, occupational hazards and hazards to the environment.

Based on the requirements, a Chemical Injection Summary Sheet (Figure 3) shall be prepared which defines the range of conditions to be covered by each dosing system. This Summary Sheet shall form part of the Basis for Design of the chemical injection system. Revisions to this list shall be discussed and agreed between the above parties.

Only chemicals for which there is a Material Safety Data Sheet shall be used; see (2.4.8). New chemicals shall only be used after testing and screening by the relevant department of the Principal.

2.3.3 Import of chemicals

IBCs are transported by road or lifted from supply boats and placed either on top of the chemical injection package or on a roof area, as directly above as possible. Transfer to storage through gravity flow shall be done manually.

Wherever possible, a single IBC laydown area should be provided to serve all chemical injection packages on the installation.

NOTE: IBCs may be loaned to the Principal by the chemical Supplier for a pre-agreed duration as part of the supply contract. IBCs are also available on the open market and may also be purchased or rented from chemical Suppliers.

2.3.4 Storage facilities

Chemical storage capacity shall provide an adequate number of days operation to safeguard against prolonged adverse weather conditions that may prevent further supplies

from being delivered, e.g., seas preventing the supply boat from unloading. The design shall take into consideration the time required at the supply base to order, receive, inspect and transfer the chemicals, along with any safety implications resulting from storage of chemicals. Effective usage volumes equivalent to 7 d, 14 d, and 28 d consumption are typically stored, depending on the remoteness of the location.

For NNM facilities / satellite platforms where the chemical supply is by IBC, the storage tanks shall be sized to optimise the frequency of manned re-filling operations.

NOTE: If the bulk storage tanks have a volume less than 3 m³, it may not be possible to transfer the contents of an IBC into storage.

2.3.5 Injection pumps

When the pump duty conditions are determined, care should be taken to ensure that there is sufficient pressure differential across the injection quill. The injection quill Manufacturer/Supplier should specify the pressure drop required. A preliminary figure of 7 bar may be used for estimation purposes only.

The sparing requirement for the pumps shall be based on the availability required in accordance with Table 1 in (2.3.1). Factors to consider are the impact that an interruption of dosing would have on the system being served and how long such an interruption may last. On an offshore platform, the availability of storage space may also be a limiting factor. As a minimum, a common non-installed spare of each pump type shall be kept in storage.

The pumps should have the provision to be locally started and stopped. For NNM offshore platforms, the option of remote starting and stopping by telemetry is not likely to be essential for operational reasons and should be avoided if possible. However, if undiluted chemicals must continue to be injected into a non-flowing system, advice should be sought from the Principal's Production Chemistry department.

Chemical treating companies have extensive experience with injection pumps and therefore it may be useful to involve the chemical Supplier in the pump selection.

Injection pumps shall be specified in accordance with (3.3).

2.3.6 Injection Rate Control Devices (IRCD)

The use of Injection Rate Control Device (IRCD) systems should be considered for chemicals that need to be injected at many locations or for which the injection rates vary significantly.

IRCD systems comprise a main pressurised header from which multiple IRCD (flow control) units draw off chemical dosages at the correct pressure for the individual injection points. A constant injection rate should always be maintained irrespective of backpressure fluctuations. These systems may reduce the number of injection pumps required (in exchange for flow controllers). The principle and operation of these systems is described in (Appendix 2).

2.3.7 Chemical usage reporting

Chemical usage reporting shall be provided for each individual chemical at a frequency defined in Table 1 in (2.3.1). It is generally good practice to reconcile the amounts of chemical sold/supplied with reported usage, to highlight any injection problems and inaccurate invoicing.

2.3.8 Calibration

At least one flow calibration gauge per chemical shall be installed for each individual injection pump. The calibration gauge shall be manifolded to the individual pumps by rigid piping or a high-integrity flexible hose.

As the calibration system is frequently used, it shall be laid out so that it is readily accessible and easily operated. The use of multiple calibration gauges shall be considered

for operational convenience and for high availability systems, in accordance with Table 1 in (2.3.1).

2.3.9 Injection points

Chemicals may be injected at various locations, e.g.:

- into onshore/offshore piping;
- downhole into production tubing;
- into the killwing of a wellhead;
- via an umbilical to a subsea wellhead or manifold;
- into an onshore/offshore vessel (seldom used).

If injection into a vessel is required, the requirements should be specified as part of the overall vessel design.

Downhole injection shall be accomplished by means of side-pockets in the completion tubing, into which a mandrel for chemical dosing is placed.

The specification for subsea injection facilities at wellheads or manifolds is covered by the wellhead or manifold specifications. Certain wellhead Suppliers offer proprietary fittings to enable chemical injection into the wellhead.

If more than one chemical is to be injected at a single injection point, consideration should be given to chemical compatibility. Advice shall be sought from the Principal's Production Chemistry Group.

2.3.10 Treatment monitoring

A chemical injection system should be closely monitored in accordance with Table 1 in (2.3.1), to ensure the effectiveness of the treatment and allow optimisation of injection rates. If harmful effects can be of a fast and irreversible nature, monitoring shall be online and automatic. If effects take place over the longer term or are reversible, monitoring shall be by routine sampling. Manual sampling shall support automatic monitoring.

2.3.11 System Cleanliness/Filtration

Chemical injection systems (storage tanks, pumps, piping, meters, control valves and injection points) shall be designed, constructed, and commissioned to such a level of cleanliness that the system cannot be blocked. In particular, subsea systems with long umbilicals or systems utilising ICRDs or proprietary flow control devices require careful attention in order to avoid blockage.

The Principal shall specify a level of system cleanliness in accordance with ISO 4406, or equivalent. Long-term system cleanliness in operation shall be ensured by means of filters specified to achieve the required performance, and suitably selected Corrosion Resistant Alloys for storage tanks and small bore piping.

In addition, the same specification for cleanliness shall be used when the IBCs are filled.

2.4 SAFETY

2.4.1 General

The chemical injection facilities shall comply with EP 95-0319.

2.4.2 Area classification

All instrumentation shall be certified as suitable for installation in the area installed; see DEP 80.00.10.10-Gen. Generally on offshore facilities, instrumentation shall at least be suitable for installation in a Zone 2 classification, gas groups IIA/B, temperature class T3, even if it is actually installed in a non-hazardous area. At onshore facilities, however, cost effective designs may operate successfully even if intrinsic safety is deliberately excluded, provided that the area classification and fluid properties (flash point > 55 °C) are suitably considered. For example, positioning the chemical injection module at an onshore oil wellhead's flowline blockvalve (corner of wellpad), may allow the certification requirement to be waived.

2.4.3 Fire protection

As chemical injection facilities may contain low flash point/flammable and/or toxic chemicals, EP 95-0350 and EP 95-0351 shall be used to develop the appropriate protection requirements. For a new facility, this is normally part of a facility-wide assessment.

2.4.4 Package location

Due to the potential hazards posed by the chemicals, the location of the chemical injection package should, as far as reasonably practicable, be kept clear of safety systems, e.g., escape and evacuation routes should not be obstructed by any toxic/hazardous fluids resulting from an incident. See also (2.4.2).

2.4.5 Shutdown / Start Up Control Logic

Each chemical injection pump should be tripped on shutdown of the process with which it is associated unless chemical injection is specifically required in a particular shutdown situation, e.g., methanol. If the design is not to include tripping on a process shutdown, advice shall be sought from the Principal's Production Chemistry group as to the possible detrimental effects of the presence of undiluted chemical(s). Likewise, where more than one chemical is involved in start up activities, advice from Production Chemistry should be sought if control logic is required in the start up sequencing.

All pneumatically driven chemical injection pumps shall be tripped out by a shutdown valve in the air/gas supply lines. For electric motor-driven pumps, the shutdown signal shall trip the power supply.

2.4.6 Safety showers

Safety shower and eyewash facilities shall be provided near to each chemical injection package and in other locations where contact with the chemicals may take place. Notices indicating the locations shall be provided and be clearly visible.

2.4.7 Colour coding

All chemical injection piping and hose end connections shall be colour-coded and labelled. Where a specific service classification is not available, the labelling shall detail the actual chemical (e.g. polyelectrolyte, ferric chloride).

Quick connectors on flexible hoses shall be colour-coded and keyed, i.e., non-interchangeable, for each chemical type.

2.4.8 Chemical information

The chemical Supplier shall provide all available safety data on MSDSs. Chemical MSDSs provide basic product information and information on hazard identification, first-aid

measures, firefighting measures, accidental release measure, handling and storage, exposure controls/personal protection, disposal considerations, transport information, regulatory and other information. Chemical MSDSs should be in accordance with ISO 11014-1.

2.5 WINTERISATION REQUIREMENTS

In general, chemicals which crystallise or drop below their pour point in their undiluted state at the specified minimum ambient temperature should be avoided, because they are usually transported in unheated IBCs.

If any chemicals become unpumpable or ineffective (either due to falling below their pour point or crystallisation point) at the specified minimum ambient temperature, the tank shall be lagged and either heat-traced or fitted with an immersion heater, and the pipework and instrumentation shall be electrically traced and insulated.

The Principal's Production Chemistry Department should be contacted for specific chemical requirements.

2.6 SUMMERISATION REQUIREMENTS

Special considerations may be required for certain operating environments, e.g., ambient temperatures in hot deserts can reach 60 °C and which may over time, together with strong sunlight, affect non metallic components. Additional precautions may also be required for electric motors. The Principal's Production Chemistry department should be contacted to determine any specific chemical requirements.

2.7 DESERT CONDITIONS

The equipment may have to be designed to prevent sand from entering vents, etc., during sandstorms. In addition, special protection for pump motors (usually available from Manufacturer) under such conditions may be considered.

2.8 DESIGN AND FABRICATION

The design and fabrication of the chemical injection facilities may be undertaken in different ways: they may be packages supplied by a Manufacturer/Supplier, they may be designed and fabricated by the Contractor as part of the module on (or in) which they are located, or they may be produced as a combination of both.

Generally, the first option is preferred.

3. EQUIPMENT DESIGN DETAILS

3.1 BULK TRANSFER TO STORAGE

Flexible hoses shall be used to connect the IBCs to the storage tank (or inlet piping). A common hose, fitted with a suitable IBC connection coupling and a hose connector, may be used for non-hazardous chemicals if the consequences of contamination are negligible.

To facilitate safe handling and to prevent contamination, dedicated hoses shall be provided for hazardous chemicals, fitted with a suitable IBC connector and a unique male/female snap connector or flange for connection to the storage tank (or inlet piping).

All hoses and flexible connectors shall be colour-coded and clearly labelled, see (2.4.7).

3.2 STORAGE TANKS

3.2.1 General

For main chemical injection packages, a single rectangular, compartmentalised style of tank is generally preferred to minimise space, weight and cost.

3.2.2 Specification

A typical design is shown in Figure 4. Nozzles not required for any given duty shall be deleted.

Storage volumes shall be determined in accordance with the requirements of (2.3.4).

Tank filling and relief back-flow connections shall be designed to minimise swirl and the build-up of static electricity.

Each tank shall be fitted with an overflow sized to discharge the maximum filling rate. The overflow shall be routed via a tundish to provide visual indication of overfill. The overflow shall be dipped and fitted with a siphon breaker where appropriate (e.g., on blanketed tanks or to prevent venting through overflow pipework). In some designs, the overflow can be eliminated, provided filling is always manually gauged and the fill container always has a smaller volume than the main storage tank.

Each tank shall have a single outlet connection that will feed the pump suction header. Tanks initially intended to hold the same chemical shall be manifolded together on the pump suction header.

Tanks shall be mounted above a drip tray. An individual drip tray shall be provided for those tanks where accidental contact of its contents with any of the other chemicals would lead to the formation of a hazardous substance. Ferric chloride storage shall always have a separate drip tray (to avoid the formation of toxic fumes which might occur on contact with other chemicals). For these cases, a separate skidded unit should be considered.

Tank vents shall be manifolded and routed to a vent at a safe location in the open air. The nature and volume of chemical stored, including the effect of gravity of the solvent, should be taken into consideration in selecting a safe location. Ferric chloride storage shall have an individual vent.

All tanks shall be fitted with a manhole (usually 610 mm. dia.) to allow internal inspection and a valved utility connection to permit washout and purging.

Both tank and frame shall be individually earthed.

If drip tray contents are drained into a facilities drain system, their compatibility with the contents of the drain fluids and possible construction materials shall be considered.

3.2.3 Design conditions

Most fabricated tanks are rectangular tanks for which there are no specific design codes, but common structural standards shall apply.

Chemical storage tanks shall be designed for an internal pressure of 0.056 barg $\pm$ 0.005 barg (at max ambient temperature).

3.2.4 Materials

Chemical storage tanks shall be constructed with materials compatible with the chemicals judged likely to be used, the location of use of the tank and the installation and operational loads (mechanical and thermal) to which they will be exposed.

Materials for storage tanks for main and subsidiary chemical injection packages shall be selected in accordance with DEP 39.01.10.11-Gen. If a chemical is not covered in DEP 39.01.10.11-Gen., the material shall be selected by a materials and corrosion specialist in consultation with the chemical Supplier. Ferric chloride duty is not currently covered by DEP 39.01.10.11; titanium shall be used for this duty.

Past experience indicates that the use of fibre-reinforced plastics (FRP) in the construction of such tanks may afford both cost and weight savings over conventional materials, e.g., carbon and stainless steels. See DEP 31.40.10.19-Gen. for guidelines and recommendations on the use of FRP on offshore facilities.

Glass-fibre-reinforced epoxy and polyester vessels shall be designed in accordance with DEP 31.22.30.14-Gen.

3.2.5 Miscellaneous

3.2.5.1 Tracing and heating

If any chemical requires heating, either tank tracing or an immersion heater (usually 2 kW capacity) shall be provided. Heaters shall be equipped with on/off thermostatic control and shall trip on low level in the tank. A paddle mixer, usually top-entry vertical or inclined, is used if a heater is provided or mixing/dilution is required. Consideration shall be given to the mixer nozzle size and to the accessibility required for paddle withdrawal and replacement.

3.2.5.2 Tank blanketing

A tank blanketing system shall be provided if flammable vapours may accumulate in a tank or the chemical may decompose. Tanks requiring blanketing shall be supplied with inert gas. Blanketed vessels shall be provided with a vacuum pressure relief valve. Tank blanketing gas shall be supplied and tanks shall be vented by means of self-regulating control valves, with a local pressure gauge. The vent shall be routed to a safe location. In addition, in systems where the presence of oxygen, injected via chemicals, has an impact on the process, tanks are usually blanketed by means of high quality nitrogen.

3.2.5.3 Dilution and mixing

Certain chemicals may require dilution before being injected (e.g. corrosion inhibitor with hydrocarbon condensate). Figure 5 shows a typical P&ID for a storage and mixing system on a manned installation. The storage tank should comprise a single tank with three compartments, one each for neat chemical, mixing and diluted chemical. A centrifugal pump is normally used to transfer between the compartments and for re-circulation during mixing.

3.3 INJECTION PUMPS

3.3.1 General

The number of chemical injection pumps shall be determined in accordance with (2.3.5).

3.3.2 Specifications

Chemical injection pumps shall be positive displacement pumps and shall be in accordance with DEP 31.29.12.30-Gen. The pumps shall lie within the Manufacturer's actual field

experience of operating temperature, maximum working pressure, material of construction, pump speed and pumped liquid properties. Diaphragm pumps with direct mechanical actuation shall not be used.

Single-head, air driven positive displacement plunger pumps with manual capacity adjustment may be used. If compressed air availability is very low (or non-existent at NNM facilities or platforms), or high reliability is required, electrically driven single-head pumps are preferred.

Single-head pumps with a low stroke rate (sizing issue) can result in imperfect dosing, which in turn will lead to batch treatment at a relatively high frequency. For some chemicals, this is not a significant problem, e.g., film-forming corrosion inhibitors. However, for scale inhibitors this may indeed be a problem, e.g., at low water-cut with maximum pump turndown. The Manufacturer shall specify the lowest capacity without sacrificing performance.

Multi-head pumps are not preferred and are subject to the approval of the Principal. Multi-head pumps can be considered provided that the capacity can be adjusted per head to suit the requirements of each individual injection point. The availability of a multi-head pump system will be lower than that of single-head pumps because failure of a single head (of a multi-head pump) will shutdown all chemical injection from this unit.

Pumps shall be standardised as far as possible, to minimise the number of spares required.

The pump suction line shall be equipped with a block valve, a Y-type strainer with 40-mesh screen, and integral drain valve. It should also have a valved connection with hose connector for flushing the pump with potable water prior to removal. The flushing connection should also be used for connection to the calibration gauge, if required.

The pump suction line shall be made as short and direct as possible to ensure that the required acceleration head is minimised. The discharge line pressure rating shall be taken back to (and include) the suction block valve.

A relief valve shall be provided on the discharge of each chemical injection pump where necessary to prevent over-pressurisation of the pump.

NOTE: With air-driven pumps, the requirements for a relief valve should be reviewed because the stalling pressure may be less than the system's maximum working pressure.

Each pump discharge line shall also be equipped with a pressure gauge, a valved and blanked connection for the pump flushing outlet stream, a check valve and a block valve.

Each pump shall have a pulsation suppression device in accordance with DEP 31.29.12.30-Gen. The pulsation suppression device may be shared between pumps that are manifolded on the discharge side. The piping arrangement shall be symmetric so that a shared pulsation dampener may be used.

The configuration of suction and discharge piping shall allow replacement or maintenance of suction and discharge valves without dismantling the main piping.

3.3.3 Installation and maintenance guidelines and operating experience for reference

On offshore platforms, particularly in harsh operating environments, only pumps required in the initial years of platform operation should be installed during module fabrication. However, the uncertainty of requirements should be weighed up against the maintainability of idle equipment.

The key to achieving high availability is regular maintenance and monitoring of malfunctions, followed by rapid startup of a backup pump or the installation of a spare.

Operating experience with injection pumps as reported in EP 2000-5721 has varied considerably. Generally, good experience has been reported in Shell Expro for electric powered pumps feeding single injection points. Shell Oil reports good experience with hydraulic pumps. Air driven pumps have also given reasonable service, with one Operating Unit having a preference for air driven pumps on offshore facilities.

3.3.4 Materials

Materials selection for the pumps' wetted parts shall be consistent with the materials selected for the tanks (and DEP 39.01.10.11-Gen), though it is common to use a higher grade material for pumps than for the piping. In all cases, the compatibility of the chemicals with the selected materials shall be confirmed by the chemical Vendor and, in case of doubt, verified by testing.

3.4 INJECTION POINTS

3.4.1 General

The number and location of chemical injection points shall be as defined by the chemical injection Summary Sheet, see Figure 3.

No quill should be fitted to any line that requires pigging on a regular basis; hence, injection for pipelines is often carried out in an upstream piping system.

3.4.2 Specification

Injection into a pipe shall be accomplished by means of injection quills located at the pipe centre-line in a location of turbulent mixing, e.g., upstream of bends, valves or pumps, and generally as far upstream as possible. The length of pipe over which full mixing is expected to occur depends on the flow regime. For example, full mixing may be expected after 10 pipe diameters along the pipe in a turbulent flow regime, but may not be achieved at all in laminar flow unless a suitable quill design is used to facilitate mixing.

Injection quills and nozzles of proprietary design, typically as shown in Figure 6 and Figure 7, shall be used to inject into both gas and liquid lines to ensure uniform dispersion. The nozzle spray characteristics should be a 60° full cone pattern for gas line injection. An injection quill does not require a nozzle when injecting into a liquid line. All quills shall be flanged. Screwed types are not acceptable.

Injection quills should be retrievable without a full shutdown of the associated process. This can be achieved by means of a high-pressure access fitting plus the appropriate retrieval tool, e.g., from Suppliers such as Corpro, Cormon, Corrocean, Panmure and Welker, or by isolation of the line containing the quill. The design must also allow for retrieval by providing sufficient head height for operation of the retrieval tool.

Each injection point shall be provided with a block valve, a non-return valve and a valved and blanked connection for flushing purposes.

Side pockets shall be specified during design of the downhole well completion equipment. Mandrels inserted in the side pockets for chemical injection shall be wireline-retrievable.

3.4.3 Design codes and conditions

Care shall be taken when selecting quills; the design shall account for all flow conditions including flow-induced vibration.

The injection branch, non-return valve and block valve shall meet the requirements of the injection line pipework and the main line into which the chemical is being injected.

3.5 PIPING DESIGN

3.5.1 Piping codes and standards

All new chemical injection pipework shall be designed in accordance with DEP 31.38.01.15-Gen. Additionally, chemical injection pipework outside packages shall be designed to comply with DEP 31.38.01.11-Gen.

Materials shall be selected in accordance with DEP 39.01.10.11-Gen. Ferric chloride duty is not currently covered by DEP 39.01.10.11; titanium shall be used for this duty. If a chemical

is not covered in DEP 39.01.10.11-Gen., the material shall be selected by a materials and corrosion specialist in consultation with the chemical Supplier.

3.5.2 Piping requirements

Distribution pipework shall be sized so that pipe diameters are as small as possible to minimise the chemical inventory. The supporting of small-bore injection piping requires special consideration.

Small-bore tubing may be used for local offtakes to injection points, or where individual distribution lines from a common manifold tend to be long and tortuous (e.g., wellhead area), but shall be continuously supported and protected from mechanical damage.

The injection pipework shall be protected against over-pressurisation (by pump or thermal). Where the injection pump's relief valve is unsuitable to protect the pipework, a separate relief valve shall be installed; see (3.3.2).

All isolation (block) valves or integral double block and bleed valves should be configured so that they meet the minimum isolation requirements as described in EP 95-0230 or, alternatively, in accordance with the Principal's policy.

Chemical injection isolation valves should be ball valves or integral double block and bleed valves in accordance with the appropriate piping class.

The chemical injection pipework for future pumps shall be installed and blanked off and preserved in accordance with DEP 70.10.70.11-Gen.

3.6 DRAINAGE

Any drainage, chemical spill or accidental overflow shall be routed in accordance with the facility's Environmental Assessment (see EP 95-0370). These flows are normally routed into the open drains system. To mitigate the potential effects of a spill/overflow, a facility to flush the drainage system with large amounts of water should be designed either as part of the chemical injection package or as part of the module design.

Due to the aggressive nature of ferric chloride, its drainage system should include a permanent water flush facility to instantly dilute any spill.

Past experience indicates that the use of glass-reinforced plastics (GRP) may afford both cost and weight savings over conventional piping materials for certain chemicals. See DEP 31.40.10.19-Gen. for guidelines and recommendations for the use of GRP.

3.7 INSTRUMENTATION AND CONTROL

3.7.1 General

Specific instrumentation requirements depend on operational requirements and so may vary from installation to installation. This Section provides general guidelines on the instrumentation requirements for the chemical injection system and specific recommendations for each type of instrument.

All instrumentation shall be in accordance with DEP 32.31.00.32-Gen.

Figure 2 illustrates the instrumentation and controls normally required for chemical injection systems.

3.7.2 Flow

The chemical usage meters shall have an accuracy of 2 % to 5 %.

Positive displacement meters are not recommended for small volumes.

Some applications call for a flow rate as low as 1 litre/day. Such low flows can best be measured by a Coriolis flow meter, i.e., a Micromotion model. When the chemical injection

pumps and relief valve are selected, consideration should be given to the potentially large pressure drops across flow sensors.

3.7.3 Level

Gauge glasses should, where possible, be of standard length and externally mounted and fitted to each storage tank, although some facilities may prefer wall-type gauge glasses. The required calibration and level gauges may also be integrated as a dual-purpose gauges provided suitable piping and valving is incorporated. Flange mounted level transmitters may also be used, e.g., from Fisher Rosemount, with the level indication, alarm, and trip functions implemented in DCS.

Each tank shall be fitted with a low level alarm that shall trip the associated injection pumps. All level switches shall be of the externally mounted float-operated type and should be mounted directly on the tank.

3.7.4 Air Pressure and Quality

Where appropriate, the air supply to the pumps shall pass through a self-regulating controller. The air supply shall be instrument air quality, see DEP 31.37.00.11-Gen.

In some OUs, air driven pumps are not allowed as air systems may be contaminated with fuel gas. If this is a concern, it must be recognised in the design. Pneumatically driven pumps may also be powered by gas, provided the design complies with environmental constraints on gas venting.

3.7.5 Relief valves

Relief valves shall be designed and installed in accordance with the requirements of equipment design codes and with API RP 520 and API RP 521 (for onshore facilities) and API RP 14C (for offshore facilities). The relief valve outlet should be connected back to the tank to minimise losses should the valve pass.

3.7.6 No flow/pump stroke monitoring

The need to detect no flow or low flow to an individual injection point shall be considered and, depending on the required availability of the injection system, provision shall be made for manual supervision or, in higher availability systems, an automatic alarm as indicated in Table 1 in (2.3.1).

The pump monitoring instrumentation, the flow measurement to each injection point, and the tank level alarms may be combined into a single package monitoring panel, depending on the overall philosophy.

Where the application calls for remote adjustment of the dose rate, this can be achieved through actuated pump stroke adjustment, an electronic variable speed drive system, or remote adjustment of an injection rate control device's setpoint.

3.8 LAYOUT ON OFFSHORE PLATFORMS

Where limited space is available, e.g., on an offshore platform, a typical main chemical injection package is laid out on three levels:

- lower level: pumps, stacked on two-tier racks;
- upper level: storage tanks;
- roof: laydown area for IBCs.

The pipe racks to accommodate the fill, vent and transfer pipework are usually located above head height at the lower and upper levels.

The chemicals should be stored so that if a tank rupture occurs the possibility of a chemical reaction is minimised; for example, oxygen scavenger should not be stored immediately adjacent to ferric chloride or scale inhibitor.

Frequently operated (control and calibration) equipment shall be readily accessible and easy to operate. It is important that both pumps and drivers are readily accessible for removal or maintenance, and that all pump isolation valves can be reached from the central or external accessway.

For subsidiary chemical injection packages, the tank, pumps and auxiliary equipment shall be located together and as close as possible to the injection point.

If the package is located on the weather deck, the lower level shall be suitably louvered or partially clad to provide weather protection to the pumps while ensuring adequate natural ventilation.

If necessary, flare radiation shielding shall be supplied to prevent the IBCs from exceeding their design temperature.

Where the IBCs are to be laid down on the package roof, the following considerations shall apply:

- the roof shall be constructed of solid plate, with a lipped edge and drain gullies. Ferric chloride and other incompatible chemical IBCs shall have separately drained areas;
- a utility washdown station shall be provided;
- since frequent access is required, one stairway and one vertical ladder shall be provided;
- guard-rails shall be provided around the top of the package if provision for access is made.

3.9 PAINTING

Exterior painting, surface preparation and application shall be in accordance with DEP 30.48.00.31-Gen.

4. REFERENCES

In this DEP reference is made to the following publications:

- NOTES: 1. Unless specifically designated by date, the latest edition of each publication shall be used, together with any amendments/supplements/revisions thereto.
2. The DEPs and most referenced external standards are available to Shell staff on the SWW (Shell Wide Web) at <http://sww.shell.com/standards>.

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Painting and coating of new equipment	DEP 30.48.00.31-Gen.
Glass-fibre reinforced epoxy, polyester and vinyl ester vessels and tanks	DEP 31.22.30.14-Gen.
Reciprocating positive displacement pumps and metering pumps (amendments/supplements to API 674 and API 675)	DEP 31.29.12.30-Gen.
Instrument air supply	DEP 31.37.00.11-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen.
Piping classes – exploration and production	DEP 31.38.01.15-Gen.
GRP Pipelines and piping systems (amendments/supplements to UKOOA documents)	DEP 31.40.10.19-Gen.
Instruments for measurement and control	DEP 32.31.00.32-Gen.
Selection of materials for life cycle performance (EP)	DEP 39.01.10.11-Gen.
Preservation of old and new equipment and piping standing idle	DEP 70.10.70.11-Gen.
Area classification (amendments/supplements to IP 15)	DEP 80.00.10.10-Gen.
Design	EP 95-0230
Safe handling of chemicals	EP 95-0319
FIREPRAN	EP 95-0350
Fire control and recovery	EP 95-0351
Environmental assessment	EP 95-0370
Corrosion control guideline for inhibited systems	EP 2000-5721

AMERICAN STANDARDS

Recommended practice for analysis, design, installation, and testing of basic surface safety systems for offshore production platforms	API RP 14C
Sizing, selection and installation of pressure-relieving devices in refineries (Part 1 & 2)	API RP 520
Guide for pressure-relieving and de-pressurising systems	API RP 521

Issued
 American
 1220
 Washington, DC 20005-4074 USA

L
 Petroleum
 Street

by:
 Institute
 Northwest

INTERNATIONAL STANDARDS

Safety data sheet for chemical products – Part 1:
Contents and order of sections ISO 11014-1

Hydraulic fluid power- fluids- method for coding the
level of contamination by solid particles ISO 4406

Issued by:
International Organisation for Standardisation
Case Postale 56
CH-1211 Geneva 20
Switzerland

*Copies can also be obtained from national standards
organizations.*

5. BIBLIOGRAPHY

NOTE: The following documents are for information only and do not form an integral part of this DEP.

Guidelines for FRP use offshore UKOOA, first edition, April 1994

Specification and recommended practice for the use
of GRP piping offshore UKOOA, first edition, March
1994

Published by:
UK Offshore Operators Association
3 Hans Crescent
London SW1X 0LN UK

6. FIGURES

FIGURE 1	ASSUMED MAIN BOUNDARIES OF SYSTEM
FIGURE 2	TYPICAL P&ID FOR STORAGE AND INJECTION OF UNDILUTED LIQUID VIA AN AIR DRIVEN PUMP
FIGURE 3	TYPICAL CHEMICAL INJECTION SYSTEM DATA SHEET
FIGURE 4	TYPICAL MAIN CHEMICAL INJECTION PACKAGE STORAGE VESSEL
FIGURE 5	TYPICAL P&ID FOR STORAGE AND MIXING FACILITIES
FIGURE 6	TYPICAL CHEMICAL INJECTION QUILL FOR INJECTION INTO GAS LINES
FIGURE 7	TYPICAL CHEMICAL INJECTION QUILL FOR INJECTION INTO LIQUID LINES
FIGURE 8	TYPICAL IRCD INSTALLATION
FIGURE 9	DETAIL OF IRCD UNIT

FIGURE 1 ASSUMED MAIN BOUNDARIES OF SYSTEM

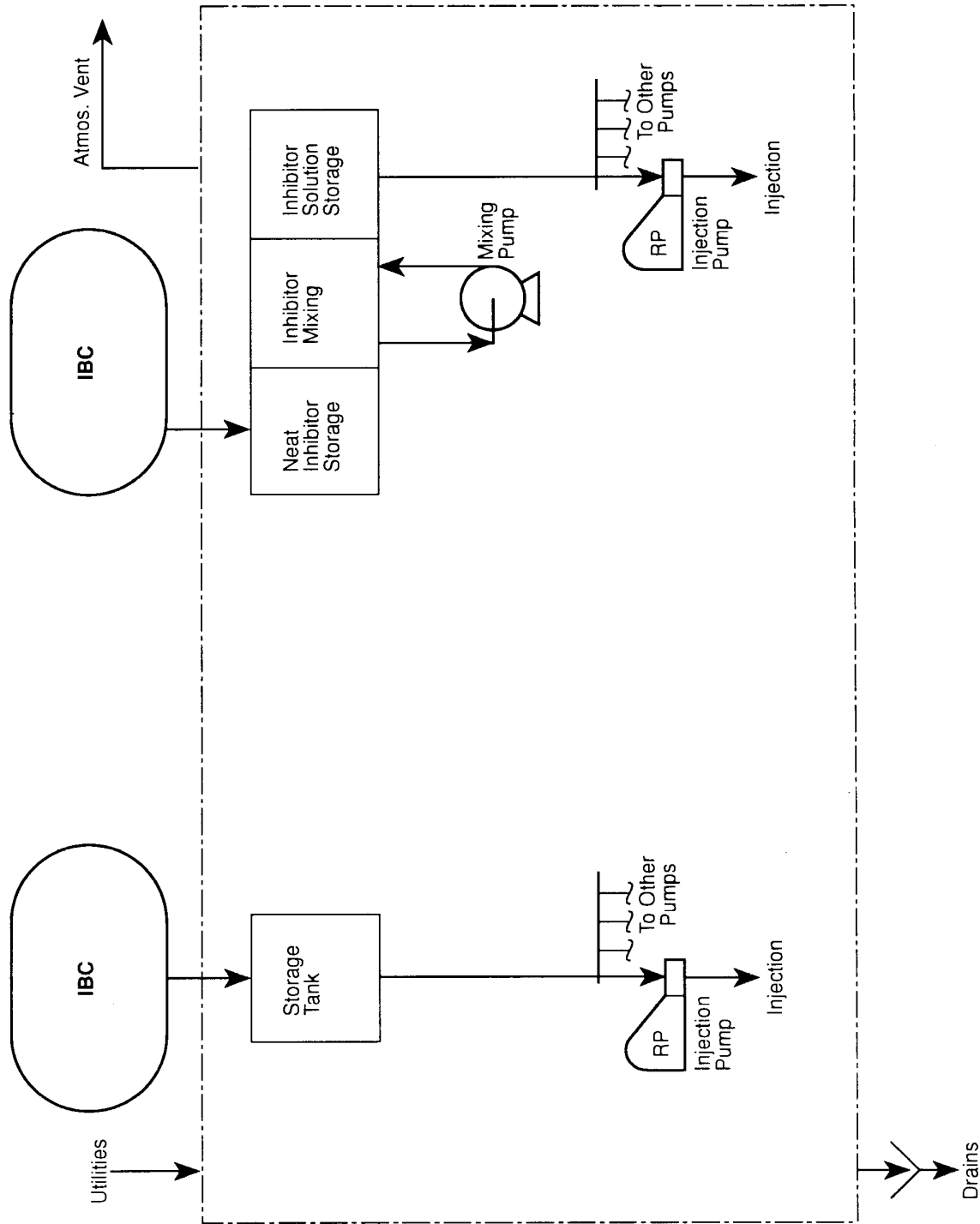


FIGURE 2 TYPICAL P&ID FOR STORAGE AND INJECTION OF UNDILUTED LIQUID (NO MIXING) VIA AN AIR OR ELECTRIC DRIVEN PUMP

NOTE: An air driven pump is shown.

NOTES:

1. Connection for potable water flush and calibration.
2. Pulsation dampener shared between pumps manifolded on discharge.
3. See EP 95.0230 for minimum isolation requirements.
4. Drip tray
5. Level gauge to be visible when operating filling valve.
6. Dip leg for overflow on blanketed tanks.
7. VPRV and Syphon breaker to be installed on blanketed tanks.
8. Route overflow and driptay drains in accordance with environmental impact statement.
9. Calibration gauge may be hardpiped to individual pumps.
10. Filtration standard to be specified in basis of Design.
11. For high availability systems meter should alarm in control room for low or no flow and have local indication.

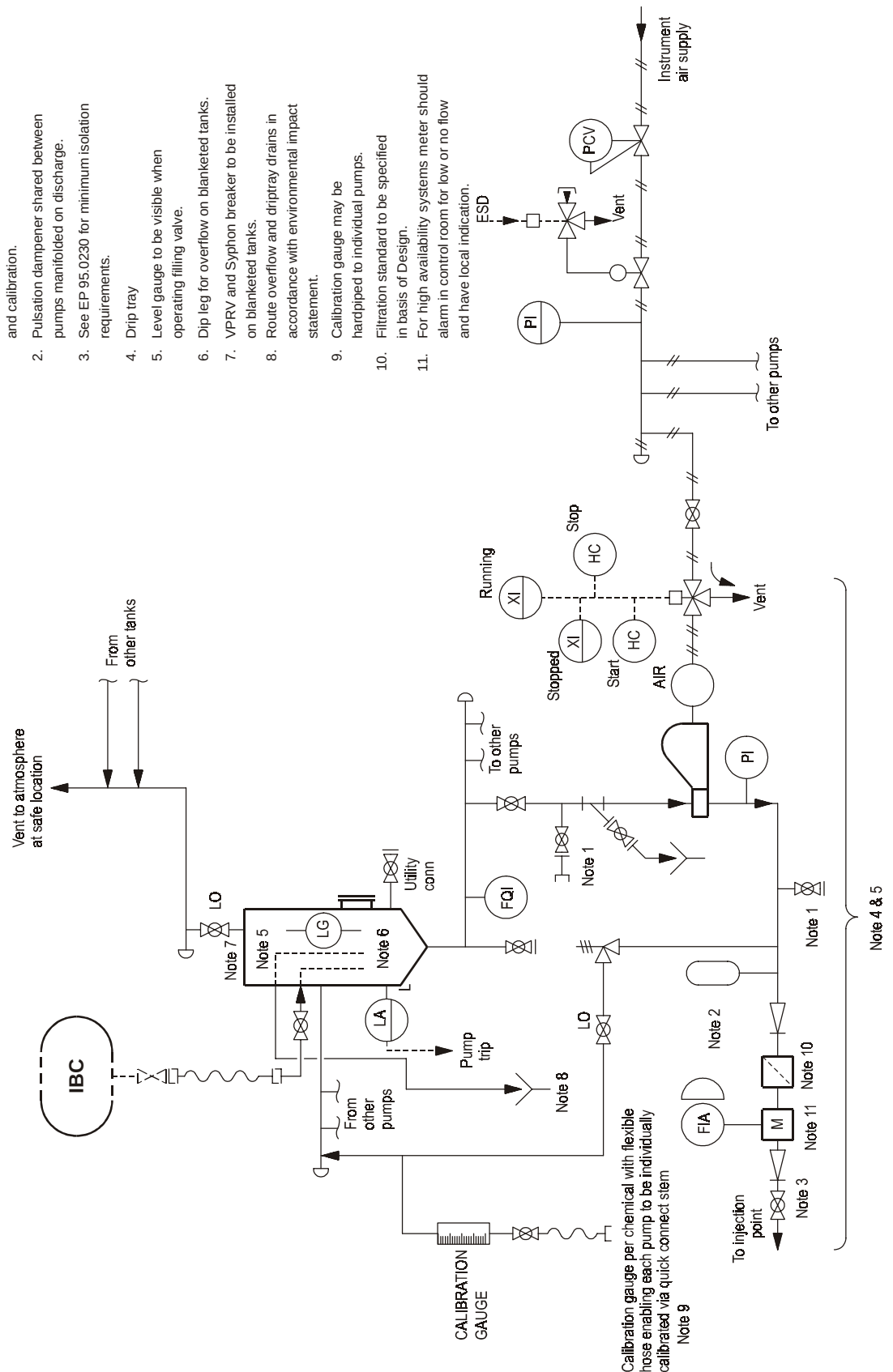
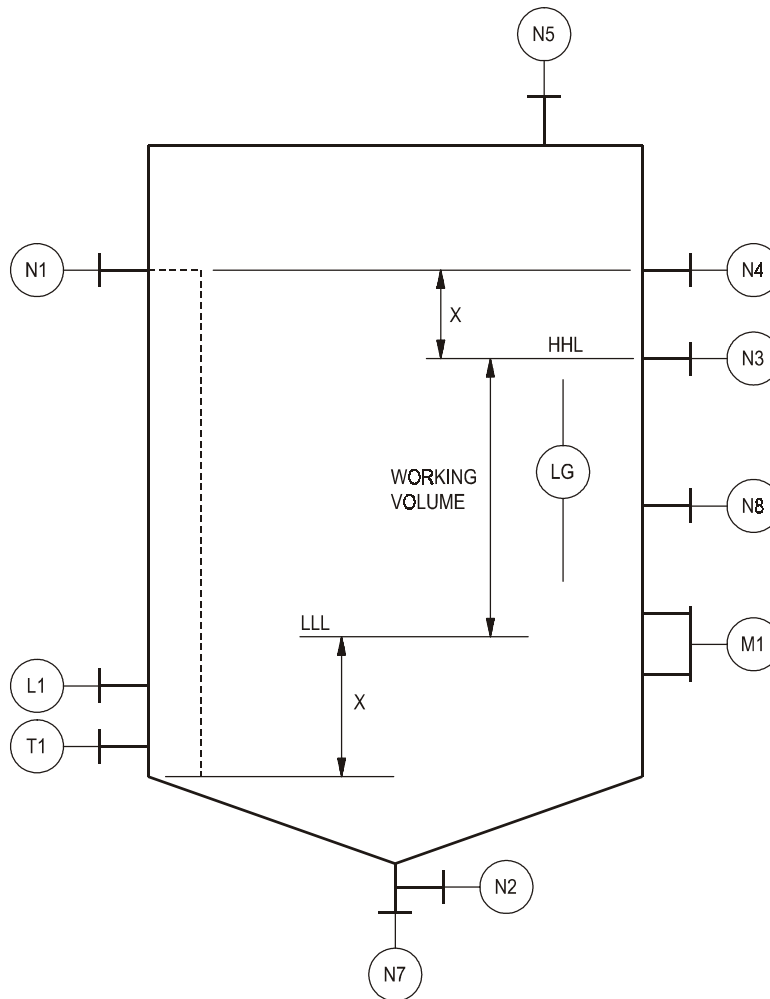


FIGURE 3 TYPICAL CHEMICAL INJECTION SYSTEM SUMMARY SHEET

DUTY	CHEMICAL	SOLVENT	DILUTION		FLOW (l/day)		S.G.	VISCOSITY	POUR POINT	FREEZING POINT (°C)	VOLUME FOR....DAYS OF STORAGE (M³) (NOTE 3)	FLASH POINT (° C)	CLEANLINESS (ISO 4406 classification)	INJECTION POINT	REMARKS (NOTE 2)
			Medium	Conc. (ppm)	Max	Min		(cP)	(° C)						

- NOTES:
1. Summary sheet to be completed for each chemical possible for each duty to enable range of requirements to be determined.
 2. Blanketing, Incompatibility with other chemicals, etc.
 3. Default values for 7/14/28 days of storage depending on remoteness of location.

FIGURE 4 TYPICAL MAIN CHEMICAL INJECTION PACKAGE STORAGE VESSEL

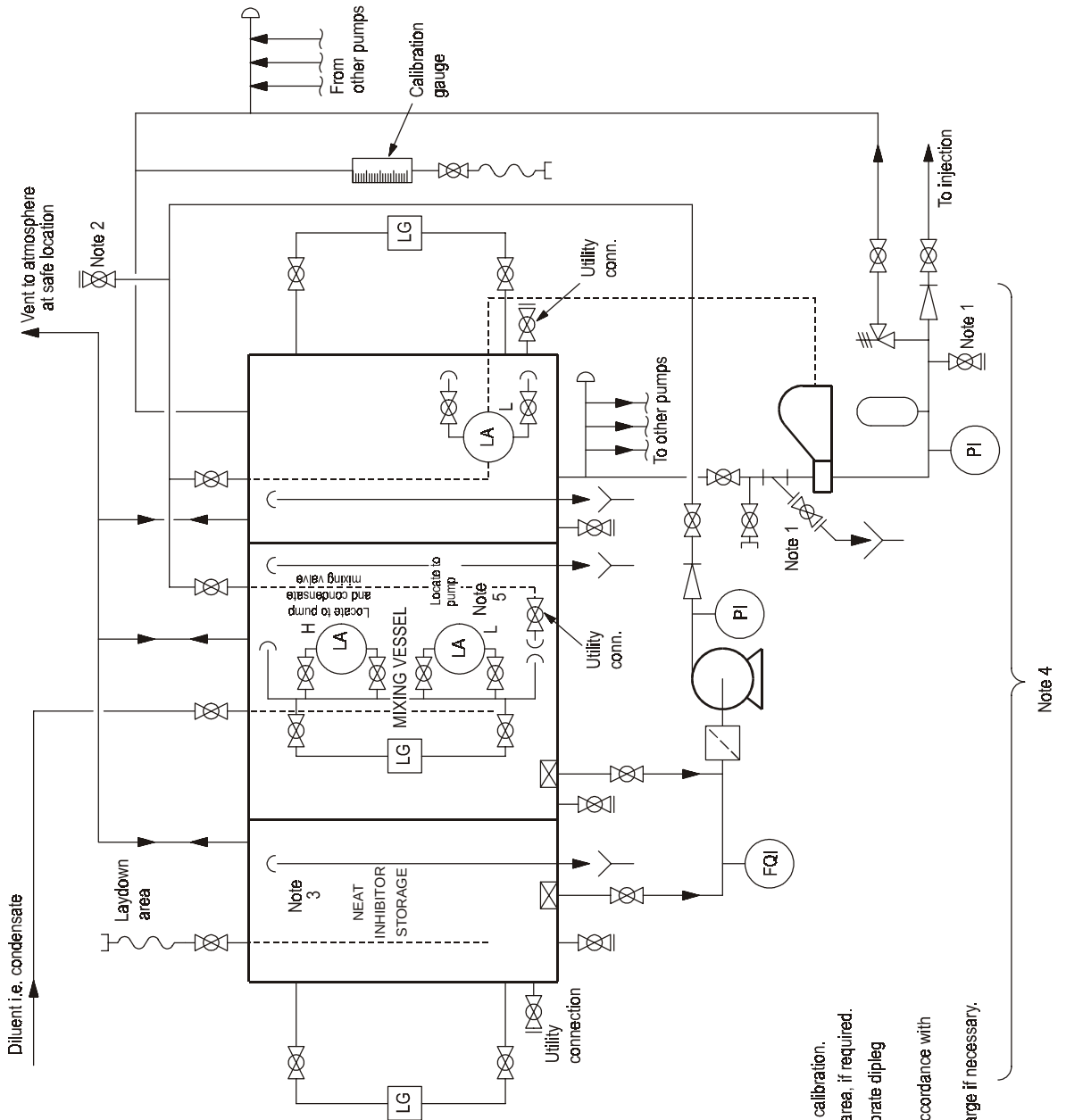


NOZZLE	DUTY	SIZE	RATING/FACING
N1	INLET	50 mm (2")	150lb RF
N2	OUTLET	75 mm (3")	150lb RF
N3	RELIEF RETURN	50 mm (2")	150lb RF
N4	OVERFLOW	75 mm (3")	150lb RF (NOTE 1)
N5	VENT	75 mm (3")	150lb RF
N7	DRAIN	50 mm (2")	150lb RF
N8	UTILITY CONNECTION	50 mm (2")	150lb RF
T1	IMMERSION HEATER	AS REQUIRED BY SERVICE	
M1	MANWAY	600 mm (24")	150lb RF
L1	LEVEL ALARM	50 mm (2")	150lb RF

NOTES:

1. Relief return (N3) and overflow (N4) may have internal flange (150lb RF) to permit connection of dip leg.
2. Dimension X to be confirmed per application.

FIGURE 5 TYPICAL P&ID FOR STORAGE AND MIXING FACILITIES



NOTES:

1. Connection for potable water flush and calibration.
2. Connection for filling IBC's at laydown area, if required.
3. Overflow on blankettted tanks to incorporate dipleg and syphon break.
4. Route overflow and driptay drains in accordance with environmental impact statement.
5. Provision of jet mixing device on discharge if necessary.

FIGURE 6 TYPICAL CHEMICAL INJECTION QUILL FOR INJECTION INTO GAS LINES

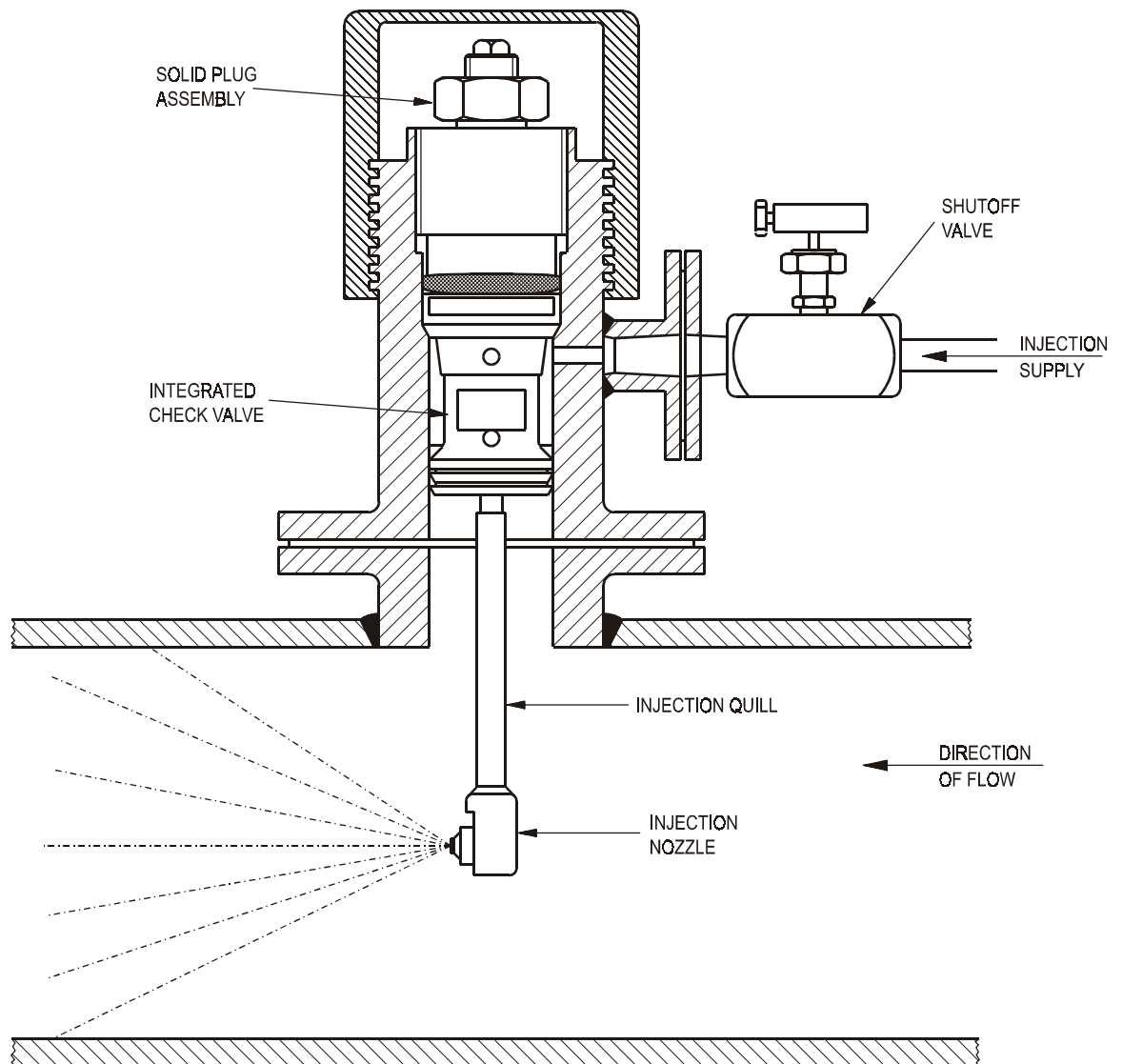


FIGURE 7 TYPICAL CHEMICAL INJECTION QUILL FOR INJECTION INTO LIQUID LINES

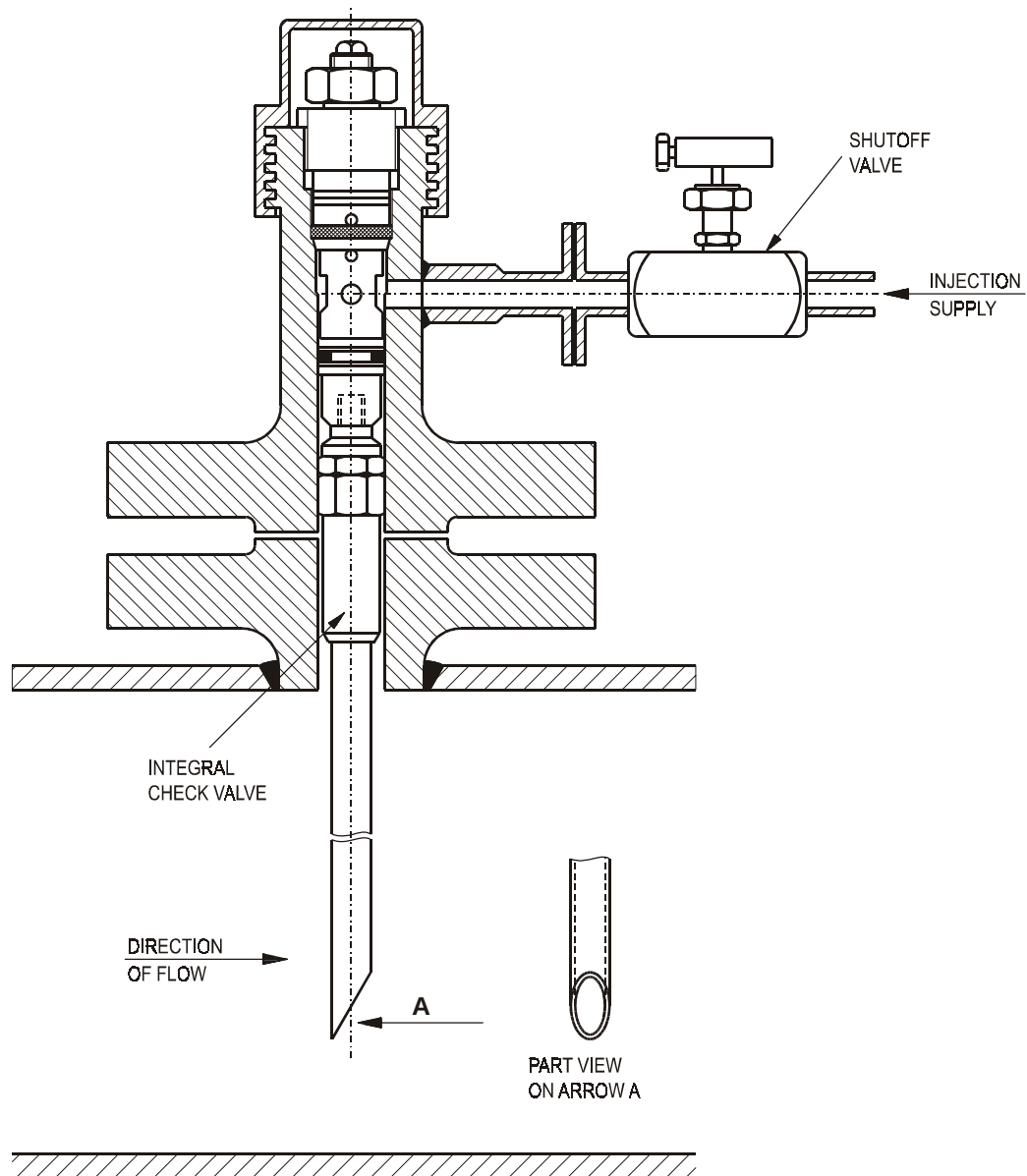


FIGURE 8 TYPICAL IRCD INSTALLATION

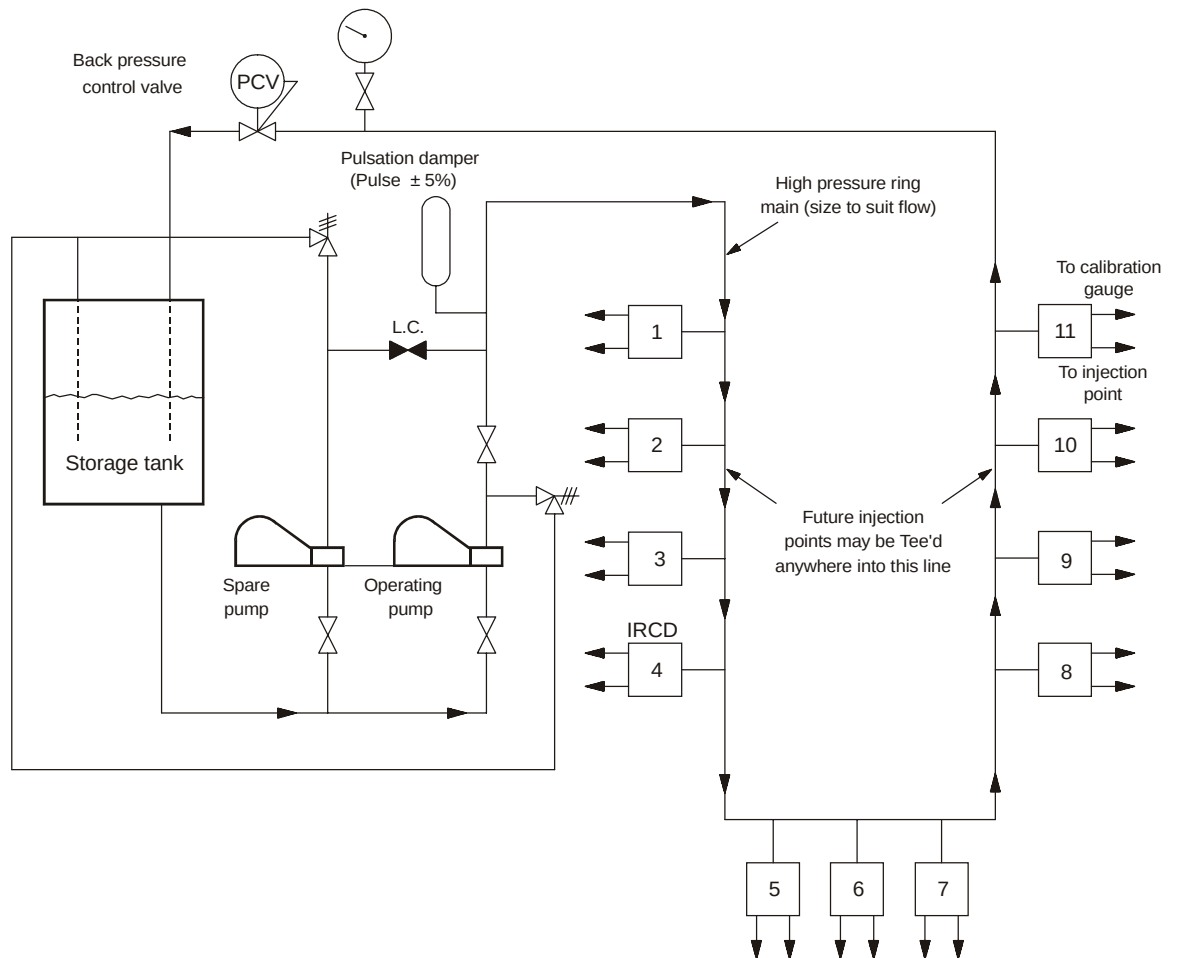
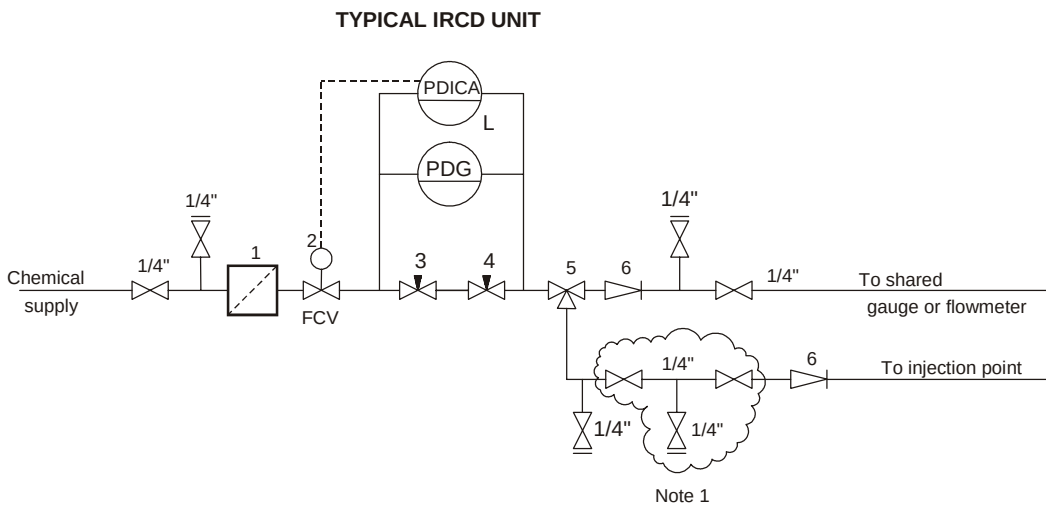


FIGURE 9 DETAIL OF IRCD UNIT



ITEM	DESCRIPTION
1	Filter
2	Regulator
3	Valve-Range
4	Valve-Flow adjust
5	Valve-Ball 3 way
6	Valve-Check

Note 1 Alternative isolation arrangements could be by integrated double block and bleed per piping classes.

APPENDIX 1 TYPICAL CHEMICAL INJECTION SERVICES

The following list is intended purely as a guide to the major injection services. The Principal shall be consulted for specialist advice on chemical selection, usage and dose rate.

Selection of chemical type for subsea systems presents additional requirements. Chemicals selected for injection into subsea systems should preferably not be water solvent based due to the risk of blockage by hydrates. Long umbilicals to subsea systems require low viscosity fluids to reduce the pressure drop over the umbilical length at the required flowrate. High levels of filtration, and selection of stable chemicals not prone to solids dropout, are also required to prevent blockage.

System	Chemical	Purpose
A. Oil Process	Demulsifier	Breaks down oil emulsions to aid oil/water separation.
	Reverse emulsion breaker/deoiler	Will coalesce oil droplets in produced water systems.
	Anti-foam	Prevents or minimises build-up of foam in production/test separators (prevents possible carry-over, improves separation efficiency).
	Pour point depressant	Reduces crude pour point to improve/maintain crude fluid characteristics.
	Wax formation inhibitor	Modifies wax crystal structure and minimises wax build-up in oil systems.
	Anti-scale	To prevent scale build-up in oil lines/equipment.
	Corrosion inhibitor	To prevent/minimise corrosion in oil systems.
	H ₂ S scavenger	To reduce H ₂ S content.
	Asphaltene dispersant	To treat/prevent asphaltenes
	Drag Reducer	To reduce flowing back pressure
	Hydrate formation inhibitor	Inhibits formation of hydrates.
B. Gas Process	Hydrate formation inhibitor	Inhibits formation of hydrates.
	Glycol	Eliminates potential of hydrates.
	Corrosion inhibitor	To prevent/minimise corrosion in gas and oil system.
C. Water Process	Anti-foam	To prevent foaming in deaerator (thereby maintaining efficient operation).
	Oxygen scavenger	To reduce oxygen content of water to be injected to zero.
	Filter aid (e.g. ferric chloride)	To assist in final filtration of water prior to injection.
	Biocide	To complete biological treatment of water prior to injection.
	Scale inhibitor	To minimise formation of scale in reservoir.

APPENDIX 2 INJECTION RATE CONTROL DEVICE SYSTEM (IRCD)

A.2.1 GENERAL

Several Manufacturer/Suppliers have developed chemical injection systems that allow accurate dosing into a (large) number of injection points without the need for separate dosing pumps. The system comprises, as a minimum, one pump (and a back-up pump) and a pressurised header from which a controlled flowrate is drawn off for each injection point. The control systems are designed to compensate for variations in the downstream system pressure at each point and maintain a constant chemical flowrate.

Savings over conventional systems may be realised by a reduction in the number of pumps, associated equipment, tubing runs and system maintenance. One of the Manufacturer/Suppliers has indicated that the system can be cost-effective with as few as four injection points. The concept also has a potential application for NNM platforms where chemical transfer is by umbilical from the main platform.

Operating experience to date with IRCDs in one OU has been poor, due to the intensive manpower needed to regularly calibrate the systems, and difficulties in ensuring that the chemical is actually being injected into all of the injection points. Fitting a flowmeter that is monitored regularly by the operator, in each branch line to each injection point, can solve the latter problem or, if the flow has to be verified in a high availability system, can trigger an alarm. Some Manufacturers offer proprietary control systems that automate the monitoring and flow adjustment tasks.

This approach may not be suitable for a subsea daisy chain, in which the individual isolation of injection points is difficult.

A.2.2 SYSTEM DETAILS

A flow scheme for a typical Injection Rate Control Device ringmain installation is shown in (Figure 8).

A single pump, sized for the maximum simultaneous chemical injection flowrate, supplies a pressurised header. The header is maintained at a constant pressure by means of either a pressure controlled spill back or pressurised accumulator vessel, and by on/off pump operation. This pressurised header, together with a vent/relief header return to the storage tank, is routed through the package or, in certain cases, around the platform.

In the main package or in the vicinity of each injection point, chemical is drawn off from the header and routed into an IRCD unit. This unit comprises: a filter, pressure regulator, 3-way valve, 'range select' and 'flow adjust' manual throttling valves and 3-way manual diverter valve (see Figure 9). The 3-way diverter valve allows the flow to be directed via a calibration header when the dosing rate is set and verified. After calibrating, the flow is directed to the injection point and the unit adjusted to produce the normal downstream injection pressure.