

DEP SPECIFICATION

**DESIGN OF INJECTION POINTS, INJECTION SYSTEMS,
AND MIX POINTS**

DEP 31.38.01.20-Gen.

February 2017

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE

DEM1



© 2017 Shell Group of companies

All rights reserved. No part of this document may be reproduced, stored in a retrieval system, published or transmitted, in any form or by any means, without the prior written permission of the copyright owner or Shell Global Solutions International BV.

This document contains information that is classified as EAR99 and, as a consequence, can neither be exported nor re-exported to any country which is under an embargo of the U.S. government pursuant to Part 746 of the Export Administration Regulations (15 C.F.R. Part 746) nor can be made available to any national of such country. In addition, the information in this document cannot be exported nor re-exported to an end-user or for an end-use that is prohibited by Part 744 of the Export Administration Regulations (15 C.F.R. Part 744).

This document has been supplied under license by Shell to:
UOP Honeywell ted.fuger@honeywell.com 19/01/2018 08:06:44

AVA Documents
Document Sharing Hub

PREFACE

DEP (Design and Engineering Practice) publications reflect the views, at the time of publication, of Shell Global Solutions International B.V. (Shell GSI) and, in some cases, of other Shell Companies.

These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal.

The right to obtain and to use DEPs is restricted, and is typically granted by Shell GSI (and in some cases by other Shell Companies) under a Service Agreement or a License Agreement. This right is granted primarily to Shell companies and other companies receiving technical advice and services from Shell GSI or another Shell Company. Consequently, three categories of users of DEPs can be distinguished:

- 1) Operating Units having a Service Agreement with Shell GSI or another Shell Company. The use of DEPs by these Operating Units is subject in all respects to the terms and conditions of the relevant Service Agreement.
- 2) Other parties who are authorised to use DEPs subject to appropriate contractual arrangements (whether as part of a Service Agreement or otherwise).
- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

Subject to any particular terms and conditions as may be set forth in specific agreements with users, Shell GSI disclaims any liability of whatsoever nature for any damage (including injury or death) suffered by any company or person whomsoever as a result of or in connection with the use, application or implementation of any DEP, combination of DEPs or any part thereof, even if it is wholly or partly caused by negligence on the part of Shell GSI or other Shell Company. The benefit of this disclaimer shall inure in all respects to Shell GSI and/or any Shell Company, or companies affiliated to these companies, that may issue DEPs or advise or require the use of DEPs.

Without prejudice to any specific terms in respect of confidentiality under relevant contractual arrangements, DEPs shall not, without the prior written consent of Shell GSI, be disclosed by users to any company or person whomsoever and the DEPs shall be used exclusively for the purpose for which they have been provided to the user. They shall be returned after use, including any copies which shall only be made by users with the express prior written consent of Shell GSI. The copyright of DEPs vests in Shell Group of companies. Users shall arrange for DEPs to be held in safe custody and Shell GSI may at any time require information satisfactory to them in order to ascertain how users implement this requirement.

All administrative queries should be directed to the DEP Administrator in Shell GSI.

TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	8
1.5	SUMMARY OF MAIN CHANGES.....	8
1.6	COMMENTS ON THIS DEP	9
1.7	DUAL UNITS.....	9
1.8	NON NORMATIVE TEXT (COMMENTARY).....	9
2.	CATEGORISATION OF MIX POINTS AND INJECTION POINTS.....	10
2.1	GENERAL	10
2.2	PROCESS ASSESSMENT	12
3.	DESIGN OF INJECTION POINTS AND CORROSIVE MIX POINTS.....	14
3.1	GENERAL	15
3.2	FLUID MECHANICS	17
3.3	MECHANICAL DESIGN	32
4.	DESIGN OF THERMAL MIX POINTS.....	38
4.1	GENERAL	38
4.2	MASS FLOW RATE RATIO.....	38
4.3	BARRIERS.....	38
4.4	MECHANICAL DESIGN	41
5.	MATERIALS OF CONSTRUCTION.....	42
5.1	MATERIALS SELECTION	42
5.2	DESIGN SERVICE LIFETIME REQUIREMENTS	43
5.3	CORROSION CONSIDERATIONS	43
5.4	EROSION CONSIDERATIONS	43
6.	INSTRUMENTATION AND CONTROL	44
7.	REFERENCES	45

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design of injection points, injection systems, and mix points for new or modified facilities. It covers the general design of the types of injection points and mix points that are encountered in refineries, chemical plants, LNG, gasification, and other similar processing facilities. Additionally, it covers the associated injection systems that are required in order to carry out these types of injections.

This DEP is limited to applications involving piping. Direct injection into equipment is not within the scope of this DEP; instead such injections are covered within DEPs specific to the applicable equipment. (e.g., DEP 31.22.05.12-Gen., DEP 31.27.00.25-Gen).

Chemical injection systems for wells and other Upstream exploration and production facilities are addressed in DEP 31.01.10.10-Gen. Many of the principles and requirements in this DEP are practices that may be considered for such applications. If any conflicts exist between DEP 31.01.10.10-Gen. and this DEP, then DEP 31.01.10.10-Gen. requirements govern for wells and other Upstream exploration and production facilities.

Subsea applications (e.g., tree, manifold, tree base) and downhole injection points are not within the scope of this DEP, although the principles and requirements in the DEP may be considered for such applications.

This DEP addresses general injection point requirements for a broad range of applications. Additional requirements concerning specific applications are covered in separate DEPs as follows:

DEP 10.02.51.11-Gen. Steam injection systems for safeguarding thermal cracking units

DEP 31.01.10.10-Gen. Chemical injection facilities for upstream production facilities

DEP 31.01.10.11-Gen. Corrosion prevention and control of water injection systems

DEP 31.38.01.19-Gen. Water injection in downstream hydroprocessing units for corrosion control

DEP 39.01.40.30-Gen. Seawater injection facilities

DEP 39.01.40.31-Gen. Produced water treatment and injection facilities

This DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 - Application of Technical Standards.

This DEP is a revision of the same number dated February 2016; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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

This DEP is intended for use in facilities related to oil refining, chemical processing, gasification, and other downstream manufacturing processes. This DEP may also be applied in other similar facilities.

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

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

1.3 DEFINITIONS

1.3.1 General definitions

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

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

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

The word **shall** indicates a requirement.

The capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.

1.3.2 Specific definitions

Term	Definition
Cocurrent Injection	An injection in which the injectant flow is introduced in the same direction as the flow of the receiving process stream.
Contacting	The degree to which intimate commingling of two streams within relatively small domains promotes rapid heat, mass, or momentum transport.
Corrosive Mix Point	Any mix point in which either the consequence of mixing or the failure of the mixing to function as designed could result in accelerated degradation rates that may compromise process equipment integrity, including brittle fracture considerations. Corrosive mix points also include those where process conditions may result in short-duration, high-rate episodic degradation.

Term	Definition
Countercurrent Injection	An injection in which the injectant flow is introduced in the opposite direction as the flow of the receiving process stream.
Crosscurrent Injection	An injection in which the injectant flow is introduced in a direction perpendicular to the flow of the receiving process stream.
Dissimilar Weld	A weld that joins two distinctly different crystallographic structures (e.g., 300 series stainless steel and carbon steel). Welds between different grades of 300 series stainless steels or between carbon steel and low-alloy steels are not included in the scope of this definition.
HSSE Critical Injection	An injection that could result in a process safety incident if either the injectant flow or the receiving process stream flow deviates from the normal control range for 24 hours. HSSE critical injection is also known as Safety Critical Injection. Examples: The injectant flow continues when the receiving process stream stops. The injectant flow is above or below the normal control range while the receiving process stream is flowing normally.
Injectant	A fluid that is being injected into a receiving process stream.
Injection Point	A mix point in which a relatively small fluid quantity is injected into a process stream to control corrosion, fouling, pH, or other chemical properties. Examples of injection points are where process chemicals or water wash are introduced into process streams.
Injection Quill	A tube or pipe element protruding some distance into a receiving process stream pipe for discharge of the injectant at a specific location in order to meet specific process requirements (e.g., mixing, contacting, wetting).
Injection System	The equipment, instrumentation, and infrastructure that is required in order to deliver the injectant to the injection point.
Mass Flow Rate Ratio	The ratio of the injectant mass flow rate, $\dot{m}_I$, to the receiving process stream mass flow rate, $\dot{m}_R$.
Mix Point	A location within a piping system where two distinct process streams with different chemical or physical (i.e. temperature or phase) properties join at a piping connection (i.e. a piping tee or similar connection). Examples of mix points include compressor recycle tie-ins to the compressor suctions, the mixing of wet and dry hydrocarbon streams at branch connections, hydrogen mixing with hydrocarbon gas streams, and heat exchanger bypass tie-ins to the main header piping.
Mixing	The gross intermingling of the injectant with the receiving process stream.

Term	Definition
Primary Flow	Fully developed flow in a straight run of piping, after 5 to 10 pipe diameters downstream of a fitting for single phase flow. For multi-phase flow, the downstream distance will be greater.
Primary Zone	A minimum of 3 pipe diameters or 300 mm (12 in) upstream of the injection point nozzle (whichever is greater) or mix point tee and at least 10 pipe diameters or past the first change in flow direction downstream of the injection point / mix point (whichever is greater). For countercurrent injection points, the primary zone extends to a minimum of 2 m (6 ft) upstream of the injection point.
Receiving Process Stream	The stream that receives the injectant; typically the receiving process stream has a greater mass flow rate than the injectant.
Removable Quill	A quill that is flange-connected, which only can be removed while the receiving system is not in operation.
Retractable Quill	A quill that is inserted through a packing gland, which allows for the removal of the quill while the receiving system is in operation.
Secondary Flow	The flow in the regions where fully developed flow is not established.
Secondary Zone	A minimum of 3 pipe diameters or 300 mm (12 in) upstream of the Primary Zone (whichever is greater) and 8 m (26 ft) or past the second flow directional change (whichever is greater) downstream of the Primary Zone.
Spray Nozzle	Device for atomizing a liquid stream for dispersion into a gas or mixed phase stream. Nozzles may generate full cone or hollow cone sprays.
Static Mixer	In-line, motionless mixing device which operates by splitting and recombining a stream multiple times in a short distance.
Thermal Mix Point	Any mix point in which either the consequence of the mixing or the failure of the mixing to function as designed could result in thermal fatigue failure of the piping.
Thermal Quill	A pipe element protruding some distance into a receiving process stream for the purpose of minimizing contact between the injectant and the pipe wall of the receiving process stream. Thermal quills are used to mitigate thermal fatigue.
Thermal Sleeve	A thin liner installed on the ID of the receiving pipe to prevent direct contact between the injectant or mixed flow fluid and the receiving pipe wall.
Wetting	An injection operation intended to cover or coat the internal surface of piping and/or downstream equipment.

1.3.3 Abbreviations

Term	Definition
APS	Ammonium Polysulfide
DCS	Distributed control system
DCU	Delayed Coking Unit
FCC	Fluidized Catalytic Cracking
FRR	Flow Rate Ratio
G/G	Injection of a gas into a gaseous receiving process stream
G/L	Injection of a gas into a liquid receiving process stream
G/T	Injection of a gas into a two-phase receiving process stream
L/G	Injection of a liquid into a gaseous receiving process stream
L/L	Injection of a liquid into a liquid receiving process stream
L/T	Injection of a liquid into a two-phase receiving process stream
P&ID	Piping and Instrumentation Diagram
PEFS	Process Engineering Flow Schemes
PFD	Process Flow Diagram
PFS	Process Flow Scheme
SME	Subject Matter Expert
T/G	Injection of a two-phase stream into a gaseous receiving process stream.
T/L	Injection of a two-phase stream into a liquid receiving process stream.
T/T	Injection of a two-phase stream into a two-phase receiving process stream
TA	Technical Authority
TS	Thermal Sleeve

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated February 2016. The only changes are to DEP cross-references to reflect changes in the DEP library in 2017

1.6 COMMENTS ON THIS DEP

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

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

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

1.7 DUAL UNITS

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

1.8 NON NORMATIVE TEXT (COMMENTARY)

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

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

2. CATEGORISATION OF MIX POINTS AND INJECTION POINTS

2.1 GENERAL

1. Any connection in a piping system in which two distinct process streams combine shall be considered a mix point.
2. All connections identified as mix points shall be assessed against the criteria in (2.2) in order to determine if these connections are categorized as injection points, corrosive mix points, or thermal mix points.

In general, like-to-like process connections, such as pump recirculation loops and valve or heat exchanger bypasses, should be considered as mix points and not as injection points, regardless of the relative flow rates.

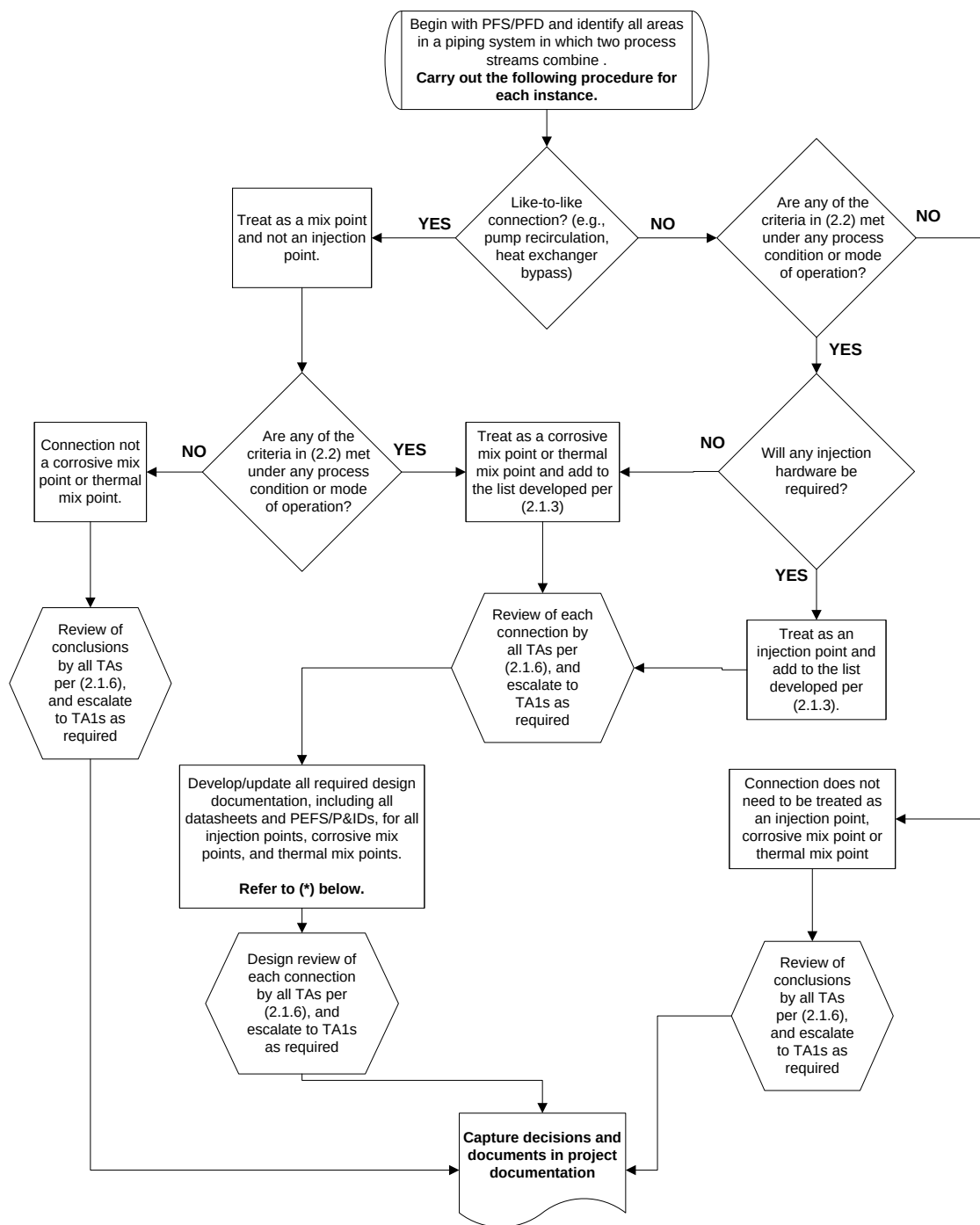
3. The Contractor shall develop, as part of the design documentation, a list that indicates all injection points, corrosive mix points, and thermal mix points that have been identified according to the criteria in (2.2).

- a. As a starting point, similar existing systems may be consulted in the course of developing the documentation.

4. All injection points, corrosive mix points, and thermal mix points that are identified according to the criteria in (2.2) shall be marked on the corresponding Process Engineering Flow Scheme (PEFS) with a note or a detailed diagram.

As per DEP 01.00.02.11-Gen., PEFS and Piping and Instrumentation Diagrams (P&ID) are interchangeable terms.

5. Both the configuration of the injection and the minimum or maximum distance requirements shall be indicated on the PEFS.
6. As a minimum, the Technical Authorities (TA) in the following disciplines SHALL [PS] review all design documentation of the injection system, including all datasheets, PEFS, and isometrics.
 - a. Process Engineering.
 - b. Fluid Flow.
 - c. Process Control.
 - d. Mechanical, Materials, and Integrity.
7. Figure 1 provides a workflow diagram that the Contractor should follow in the course of developing the design documentation for all injection points, corrosive mix points, and thermal mix points.

Figure 1 Typical workflow diagram for the design of injection points, corrosive mix points, and thermal mix points

(*) **Early DEFINE/Pre-FEED:** Assessment made, PFS/PFD marked up
Late DEFINE/FEED: PEFS/P&ID marked up including all required notes
Early EXECUTE: Datasheets and design documentation developed and issued to all TAs for review
Mid EXECUTE: Vendor data reviewed by SME for vendor-provided equipment
Late EXECUTE: Final design documentation issued to all TAs for "Final" Review

2.2 PROCESS ASSESSMENT

2.2.1 Stream connections

2.2.1.1 General

1. A mix point between two distinct process streams shall be designed as an injection point, a corrosive mix point, or a thermal mix point, whichever is applicable, whenever contact either between the streams or between a stream and any potentially-impacted process equipment has the potential to create a significant physical or chemical interaction, as described further in (2.2.1.2) through and including (2.2.1.5).
2. Process streams shall be regarded as distinct if they differ from one another with respect to phase or chemical composition, velocity or temperature in a manner that leads to any of the scenarios described in (2.2.1.2) through (2.2.1.5).
3. If exothermic or endothermic reactions are expected, then the design of the system shall be able to accommodate the maximum temperatures.

2.2.1.2 Phase composition

1. A connection between two process streams SHALL [PS] be designed as an injection point or a corrosive mix point, whichever is applicable, if the intentional or potential interaction results in at least one of the following:
 - a. the formation of any new phase of matter, whether temporary or permanent, including any additional phases of the same types already present in the receiving process stream;
Example: Cooling a vapour stream to the aqueous dew point or salt formation temperature.
 - b. a change in flow regime, as determined by Shell Flow Explorer or a Principal-approved equivalent software package.

2.2.1.3 Chemical composition

1. A connection between two process streams SHALL [PS] be designed as an injection point or a corrosive mix point, whichever is applicable, if the injectant contains at least one of the following:
 - a. stream components or trace contaminants that can react with the receiving process stream (including any trace contaminants that may be present in the receiving process stream) leading to erosion or corrosion of equipment surfaces;
 - b. stream components or contaminants which, alone or in combination with other species or contaminants present in the mixed stream, can cause erosion or corrosion of equipment surfaces;
 - c. stream components or contaminants that can undergo catalytic interactions with piping or equipment surfaces.

2.2.1.4 Velocity

1. The momentum flux ratio of the injectant versus the receiving process stream, R, shall be determined as (Equation 1)

$$R = \frac{\rho_i V_i^2}{\rho_r V_r^2} \quad \text{Eqn 1}$$

where:

ρ is the average steady state density

V is the average steady state velocity

i refers to injectant stream

r refers to receiving process stream.

2. For systems with multiple steady states, each steady state mode shall be assessed separately
3. A connection between two process streams SHALL [PS] be designed as an injection point or a corrosive mix point, whichever is applicable, if the injectant is injected at an average steady state velocity sufficient to lead to at least one of the following:
 - a. for injection points involving cocurrent injection, if the value of R calculated in (Equation 1) is greater than 2;
 - b. for injection points involving crosscurrent injections, if the value of R calculated in (Equation 1) is greater than 0.1;
 - c. for injection points the injection is carried out in an orientation other than cocurrent or crosscurrent;
 - d. for either injection points or corrosive mix points, if the volumetric or thermal effects associated with chemical or physical phenomena (e.g., reaction, evaporation, condensation, flashing) in the mixed stream could produce velocities beyond the erosion/corrosion limits of the system.

2.2.1.5 Temperature

- Except for connections to flare header systems, a connection between two process streams SHALL [PS] be designed as an injection point or thermal mix point, whichever is applicable, if the temperature difference between the injectant and receiving process stream exceeds the temperature limit shown in Table 1.

Table 1 Temperature Differential Limits

Pipe Material	Type of Mixing	Differential Temperature Limit ($\Delta^{\circ}\text{C}$)	Differential Temperature Limit ($\Delta^{\circ}\text{F}$)
Austenitic Stainless Steel	L/G, L/T, T/T, or T/G	83 $^{\circ}\text{C}$	150 $^{\circ}\text{F}$
	L/L, G/G, G/L, or G/T	169 $^{\circ}\text{C}$	305 $^{\circ}\text{F}$
Carbon Steel and Low Alloy Steel	L/G, L/T, T/T, or T/G	114 $^{\circ}\text{C}$	205 $^{\circ}\text{F}$
	L/L, G/G, G/L, or G/T	211 $^{\circ}\text{C}$	380 $^{\circ}\text{F}$
NOTES: - Terminology for Type of mixing for streams A/B, where A = injectant stream phase / B = receiving process stream phase. - G = Gas phase, L = Liquid phase, T = Two phase. - The differential temperature limits in Table 1 are applicable to injection points and mix points where the receiving process stream composition is primarily comprised of hydrogen, hydrocarbons, or other organic compounds. These temperature limits do not apply to design of specialty applications like steam desuperheaters, water injection into process streams (such as hydroprocessing water wash applications), or for systems where one or both of the process streams contain more than 10 wt% water.			

- For flare headers, the Principal shall determine the applicability of the differential temperature limits in Table 1.
- For the specialty applications referred to in Note 3 of Table 1, the Contractor shall seek design input from the Principal.
- For materials other than austenitic stainless steel and carbon steel/low alloy steel, the Contractor shall consult further with the Principal regarding acceptable temperature differential limits.
- The potential for chemical or physical phenomenon (e.g., reaction, evaporation, condensation, flashing) that can result from the injection should be reflected when evaluating the largest differential temperature.
- When establishing the differential temperature, the operating condition leading to the largest differential should be used as the basis for the evaluation, including normal operation, start-up, shut-down, upset, and any abnormal operating modes that may result in a differential temperature that is higher than that experienced during normal operation.

3. DESIGN OF INJECTION POINTS AND CORROSIVE MIX POINTS

This section is dedicated to injection points, injection systems, and corrosive mix points. Refer to (4) for thermal mix points.