Engineering Design Practice

Process

Process Design

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1. INTRODUCTION

The APA Technical Practice (ATP) aims to achieve sound engineering and design practice through standardisation. We endeavour to make ATP sufficiently flexible to allow engineers to adapt the information in the ATP to project, asset, or customer conditions and requirements. This is of particular importance where the standard may not cover all situations or needs of use.

APA staff and its Contractors shall be solely responsible for applying ATP in the context of legal, statutory and approvals requirements to achieve the required engineering design and quality of work. For those requirements not specifically covered, the designer shall use a recognised engineering practice or standard to accomplish as a minimum the same level of integrity as reflected in the ATP. If in doubt, the Contractor shall, without detracting from their responsibility, consult APA.

Refer to APA's Engineering Glossary [Ref.1] for terms and abbreviations not listed in the appendices.

1.1 Conflicts and Waivers

Conflicts between this standard and other applicable ATP or international, national standards, codes and industry practices shall be resolved in writing by the APA Standards and Assurance team.

Requests for waivers from this standard shall follow the ATP Waiver procedure in [Ref.2].

1.2 Order of Precedence

Refer to the order of precedence of standards in Engineering Standards (Development and Application) Procedure [Ref.3].

2. PURPOSE AND SCOPE

A design may be influenced by factors, including process requirements, economics, environmental and safety. This document provides an overview of Process design requirements and conditions with sufficient content to allow an engineer to use expected and best design practices.

This document also provides and overview and index of the supporting process EDPs and TPs within APA. This document acts as the central document to coordinate the specific requirements laid out in the other process EDPs as well as the templates and other tools which support them.

A comprehensive listing as well as a diagram of process documents and their relationships is included in the appendices.

3. PROCESS DESIGN

3.1 Emission Control Design

APA Climate Transition Plan outlines the company's commitment to achieving net-zero greenhouse gas emissions by 2050. The plan includes a range of strategies to reduce emissions, including increasing the use of renewable energy sources, transitioning to lower-emission fuels, and improving energy efficiency. APA aims to reduce its methane emissions, through the implementation of the Methane Guiding Principles and is committed to ensuring that all opportunities to reduce emissions are in line with the relevant Australian Federal, State, and Territory legislation.

For all greenfield and brownfield projects, the Net Zero requirements shall be considered to eliminate or reduce any risk of harm from Scope 1 and 2 GHG emissions i.e., avoid or minimise Scope 1 and Scope 2 emissions or where and so far as is reasonably practicable.

The designer(s) shall apply to the commercial decision-making processes in APA's Internal Carbon Pricing Procedure, [Ref.24], to determine the best options to avoid or abate emissions.

See also the Climate Change Standard [Ref.23] and The Methane Guiding Principles [Ref.33].

Table 1 EDPs and Best Practice Guides covering emissions control designs

Doc. Number	Doc. Name
ATP-EDP-HSE-0001	Emission Control [Ref.4]
Subject	**Best Practice Guide (BPG)**
Design:	
Methane Guiding Principles	The Methane Guiding Principles (MGP) [Ref.33]
Design and Construction	MGP BPG for Engineering Design and Construction [Link]
Flaring	MGP BPG for Flaring [Link]
Energy Use	MGP BPG for Energy Use [Link]
Equipment Leaks	MGP BPG for Equipment Leaks [Link]
Venting	MGP BPG for Venting [Link]
Pneumatic Devices	MGP BPG for Pneumatic Devices [Link]
Operations:	
Operational Repairs	MGP BPG for Operational Repairs [Link]
Continual Improvement	MGP BPG for Continual Improvement [Link]
Detection and Measurement	MGP BPG for Identification, Detection, Measurement and Quantification [Link]
Transmission, Storage and Distribution	MGP BPG for Transmission, Storage, LNG Terminals and Distribution [Link]

3.2 Inherently Safer Design

Throughout the engineering design process, a special emphasis is placed on process safety. This is due to the extreme hazards inherent in oil and gas processing. Process engineering is particularly concerned with the high consequence, low probability types of hazards though notes that lower consequence hazards are also not to be ignored. APA achieves a consistent and high degree of process safety through the Inherently Safer Design process [Ref.12].

The Inherently Safer Design [Ref.12] emphasises the preference for process safety to primarily be inherent in the design rather than being achieved through additional design elements. The common scenarios where inherent safety is not technically or economically feasible are covered by the following EDPs (also listed in [Appendix A]):

Table 2 EDPs and Guides covering non-inherently safe designs

Doc. Number	Doc. Name
Passive Safety:	
ATP-EDP-Q-0003	Flares and Vents, [Ref.7], (Vents are considered passive and flares active though a malfunctioning flare will still function as a vent)
530-EDP-Q-0005	Plume Dispersion and Radiation
530-EDP-Q-0006	Overpressure Protection Philosophy, [Ref.8] (Also includes active safety)
530-EDP-Q-0008	Ignition Control, (Also includes some active safety)
ATP-EDP-Q-0004	Process Input into Pipeline Isolation Plans (although closure of valves requires procedural intervention)
Active Safety:	
530-EDP-Q-0001	Sizing and Selection of Relief Devices [Ref.5]
530-EDP-J-0004	Purging, Pressurisation and Ventilation of Buildings, Rooms and Enclosures
530-EDP-Q-0025	Facilities Shutdown
530-GD-Q-0005	Managing MAOP & MOP Limitations for AS2885 Pipelines Guideline
530-PHL-Z-0001	Alarm Philosophy [Ref.14]
Procedural Safety:	
Not generally covered by process engineering design. Inherent, passive and active systems may be required to improve procedural safety.	
Note: The selection and implementation of Passive Safety is preferred to Active Safety which is preferred to Procedural Safety.	

3.2.1 Safe Operating Limits

Figure 1 visualises how process design achieves process safety through ensuring plant process conditions cannot exceed a specified “Do Not Exceed” limit (DNL). This is achieved by appropriate selection of Design Conditions (see Section 3.3), complemented by the design of process control system(s), and required layer(s) of protection. This diagram is indicative, and designers must use engineering judgement to set Safe Operating Limits (SOL) and associated alarms and trip setpoints to meet the intent achieving process safety.

Designers shall ensure that adequate layers of protection and associated design margins are incorporated into the design so that the “Do Not Exceed Limit” is never exceeded during either normal or transient (upset / failure) operations.

The full Possible Operating Envelope (including potential failures of equipment/controls) shall be assessed, and the unmitigated (worst case) consequence determined. Unexpected operation at maximum equipment capacity (e.g. fully opened control valve, maximum flow/pressure from a pump or compressor) shall be considered. This unmitigated consequence shall inform project/facility risk assessments (e.g. HAZOP, LOPA) to ensure that the design provides adequate layer(s) of protection commensurate with the process safety risk.

If any hazard is identified that may lead to a Major Accident Event, it is unacceptable to rely only upon a procedure or operator intervention (e.g. an alarm requiring operator response) to prevent a SOL exceedance.

Inherently Safer Design (ISD) principles to reduce or permanently eliminate the hazard shall be applied as per the Inherently Safer Design [Ref.12]. Where a hazard leading to a Major Accident Event is identified, at a minimum engineering design shall include an automated response (e.g. trip) to avoid the potential consequence. Preferentially, the equipment and/or piping sizing shall be modified to minimise consequence severity.

Where an instrumented electronic or electrical system is used to implement active safety measures, Functional Safety Planning and Management is mandatory as per the Functional Safety Management Plan [Ref.15].

Other requirements include:

- Process control systems should be designed to achieve required steady state and dynamic accuracy, with appropriate controller equipment selection and tuning.
- Controllers should always operate the plant within the Normal Operating Limits and always respond to alarms. Designers must specify the required alarm response (as required by the Alarm Philosophy, [Ref.14], and Alarm Design Procedure,[Ref.16]).
- The size of the troubleshooting zone (margin between alarm and trip setpoints) should be adequate to allow Controllers to take effective action in response to alarm(s) to return the process back to the normal operating envelope.
- Where the potential exists for upset conditions (e.g. equipment failure) to reach or exceed Safe Operating Limits, the size of the emergency response zone (margin between trip setpoint and DNL) must be adequate so that when considering the accuracy and response characteristic of the trip(s), the DNL is never exceeded.
- All facilities must have clearly defined SOLs and DNLs. Projects must deliver a facility Safe Operating Limit Register (SOLR) based on the Safe Operating Limits Register Engineering Template [Ref.21]. As part of Asset Establishment the SOLR data must be uploaded into the Operations SOL database.

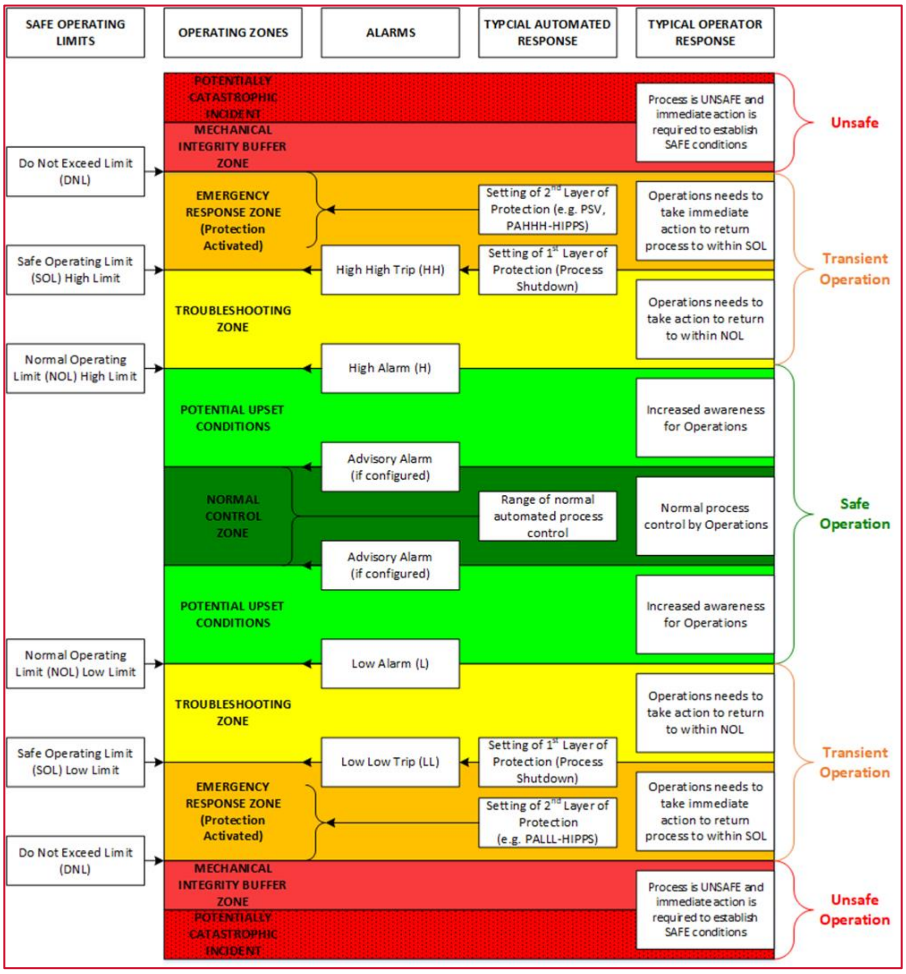


Figure 1 Process Plant Safe Operating Limits

Table 3 Plant Operating Limits

Limit	Definition
Do Not Exceed Limit (DNL)	The upper or lower limit that must not be exceeded during either normal (steady state) or transient operation as established by applicable codes and standards. The process may never be operated at or outside its Do Not Exceed Limits, and all protection systems (manual and automatic) must be designed to prevent this. • For AS1210 & ASME vessels protected by a single PSV, DNL can be up to 110% of Design Pressure to include code permitted accumulation (for multiple PSVs up to 116% is allowed). • For Brownfields station piping, the DNL may be set to take credit for B31.3 clause 304.2.4 allowed exceedances. For Greenfields station piping setting DNL = Design Pressure is APA's preferred approach. • For AS2885 Pipelines, DNL = 110% MOP. • Temperature should be max/min design temperature, for coincident design max/min pressure conditions • The values of the DNL nominated in the SOL register shall be the lowest of the DNL limits in the system e.g. if the system comprises of an AS2885 pipeline and station piping, DNL may be set by piping DNL set at design pressure which is < pipeline DNL at 110% MOP/MAOP.
Safe Operating Limit (SOL)	Limits established for critical process parameters, such as temperature, pressure, level, flow, concentration, piping Likelihood of Failure (LOF) etc based on a combination of equipment design limits and the dynamics of the process. The Safe Operating Limit represents the point at which operational trouble shooting ceases and immediate predetermined actions (either trip or alarm to trigger operator response) are taken to bring the process back to a safe state. A process must never be intentionally operated outside its Safe Operating Limit. *Note:* SOL shall only be defined for key safety related parameters and not every instrument needs to have an associated SOL. For a given process parameter only "high" or "low" SOL may be relevant, not both e.g. flow related SOLs for piping typically only relate to high not low deviations.
Normal Operating Limit (NOL)	The limit that should not be exceeded during normal (steady state) operation. The normal operating range is based on target operating conditions, plus an allowance for typical operational variability due to potential process condition changes and control system response.

3.3 Design Conditions

One of the key opportunities to achieve inherently safer design is in the selection of design conditions that encompass the entire range of possible process conditions (Passive Safety). Wherever possible this method shall be adopted, however where the increased expense cannot be justified other safety management strategies to limit the process conditions to within the design conditions may be used.

The following design codes are commonly used for vessels and tanks design in the oil and gas industry:

Table 4 Pressure Vessel and Storage Tank Design Codes

Design Code	Application
API 650	Large Oil Tanks [Ref.32]
AS 1210	Pressure Vessels [Ref.25]
AS 1692	Small Tanks [Ref.26]
ASME VIII	Pressure Vessels [Ref.29]

Other commonly encountered process equipment is covered by the following EDPs, (also listed in [Appendix A]):

Table 5 Process Equipment Design EDPs

Doc. Number	Application
ATP-EDP-Q-0003	Flares and Vents [Ref.7]
530-EDP-Q-0012	Filters, Filter-Separators and Coalescing Filters
530-EDP-Q-0013	2 Phase Separator and KO Drum Sizing
ATP-EDP-Q-0019	Drain Systems
ATP-EDP-Q-0020	Heat Exchangers and ACHEs

3.3.1 Design Pressure

Design pressure is one of the key design conditions to be selected for any pressure-retaining process equipment. The design pressure shall be selected consistent with the guidance provided in the Overpressure Protection Philosophy [Ref.8] and Managing MAOP & MOP Limitations [Ref.13]. Where a relief valve is required to provide adequate overpressure protection it shall be provided consistent with the Sizing and Selection of Relief Devices, [Ref.5].

3.3.2 Maximum Design Temperature

The maximum design temperature according to NORSOK, [Ref.27], may be selected with no design margin in cases where the maximum operating temperature is known accurately (e.g., plant inlet facilities where the incoming gas is at equilibrium with ground temperature).

Progressively larger design margins are required as the process and ambient conditions becomes less certain. Where the maximum operating temperature is unknown, a design margin of 30 °C above the normal operating temperature should be used. Wherever the system is not self-limiting, a high-temperature trip shall be provided and validated in accordance with the Functional Safety Management Plan [Ref.15]. The high-temperature trip may need to be set below the design temperature to compensate for dynamic effects.

Selection of a higher design temperature than necessary may lead to the selection of a non-standard material or higher-pressure class rating which results in a step-change of capital cost. This should be avoided wherever possible.

Methods of selection of specific equipment maximum design temperatures are given in Sections 3.3.2.1 - 3.3.2.4 below.

3.3.2.1 Compressor Outlet

The maximum operating temperature at compressor outlet is given by:

Table 6 Compressor Maximum Operating Temperature

Scenario	Margin
Compressor curves available	0 °C above predicted temperature at surge conditions when operating at maximum speed. **Note**: This presumes the compressor is unlikely to be restaged for higher head over its operating life, which would normally be true. If future higher head is anticipated, future worst-case condition should be considered.
Compressor curves not available	15 °C above predicted temperature at design flow and maximum normal differential pressure.

The maximum design temperature at compressor outlet is given by the maximum operating temperature plus:

- 15 °C to allow for inaccuracies of compressor curves (if not known), as well as efficiency reductions over time

Air cooled heat exchangers associated with compressors should allow 5 °C margin above maximum operating temperature for their outlet design temperature.

3.3.2.2 Compressor Suction Scrubber

Compressor suction scrubber maximum design temperature is the maximum of:

- Maximum recycle temperature = maximum compressor/cooler discharge temperature (depending on whether cooled or hot recycle) trip less JT cooling effect across recycle or anti-surge valve.
- Maximum temperature due to settle out conditions
- Operating temperature plus a 5 °C margin

3.3.2.3 Water Bath Heaters

The maximum design temperature should include (at least) a 5 °C margin above maximum operating temperature to account for transients and control inaccuracy.

Water bath heaters should be designed so that the maximum water temperature is equal to or lower than the gas outlet downstream material design temperature, as at low flow rates the gas outlet temperature will trend towards the water temperature.

3.3.2.4 Solar Radiation

The maximum design temperature must be at least equal to maximum possible surface temperature due to solar radiation, which is defined in the Line Sizing Guide, [Ref.6], for piping (60-65 °C, depending on region). No margin above these values is required.[1] .

3.3.3 Minimum Design Temperature

The selection of minimum design temperature according to NORSOK, [Ref.27], is similar to maximum design temperature however certain materials become unsuitable at low temperatures due to changes in the metal structure. The following represents the typical minimum temperature limits based on common materials:

[1] 65 °C is based on that the allowable stress change which, as per ASME B31.3, [Ref.28], changes at 65 °C for some materials and components used in the piping systems. Therefore the 65 °C makes use of the max. allowable stresses for these components. The next change is at 100 °C.

Table 7 Temperature Limits of Common Materials

Material	Minimum Temperature Limit
Pipeline Steel	- 10 °C **Note**: Many pipelines have higher minimum temperature limits as determined by the required Charpy impact tests of pipeline steel. Guidance shall be obtained from the lead pipeline engineer as to the real minimum design temperature of a specific pipeline.
Carbon steel for vessels and plant piping	- 29 °C
Low temperature carbon steel for vessels and plant piping	- 45 °C
Stainless steel for vessels and plant piping	-104 °C **Note**: Stainless steels may be suitable for much lower temperatures but require special treatment in fabrication.

Changes in minimum design temperature below these limits generally results in a step-change in capital cost and should be avoided. Note that lower temperatures are also permitted when the material is under low stress. Such situations shall be coordinated with the mechanical engineer. Many existing installations have minimum temperature limits higher than the values above. Where minimum temperature is not known for existing equipment, the value shall be obtained from the mechanical engineer.

The minimum design temperature shall be calculated as the minimum of:

Table 8 Minimum Design Temperature Criteria

Material	Minimum Temperature Limit
Minimum ambient temperature	5 °C (depending on historical accuracy of data) **Note**: ambient refers to air or ground temperature dependent on the installed location.
Minimum normal operating temperature	5 °C
Minimum transient temperature (start-up, shutdown, other upset)	5 °C
Minimum depressuring temperature	Depends on the depressuring methodology used. (See HYSYS SS / Dynamic Simulation, [Ref.9] and Flares and Vents [Ref.7].)

Consideration should be given to providing lower design temperatures at locations to facilitate start-up after depressuring. Selection of lower design temperatures may also facilitate restarting more quickly avoiding the need to wait for the plant to warm up to ambient temperatures.

3.3.4 Other Design Considerations

The effects of other design parameters such as flow, differential pressure, turndown and dynamic response as well as controlling GHG emissions, are discussed in more detail in the relevant EDPs for specific equipment. They should be referred to prior to making the relevant technology selection, (also listed in [Appendix A]):

Table 9 EDPs for specific equipment

Doc. Number	Doc. Name
530-EDP-Q-0011	Generic Compressor Station Process Design Specification
530-EDP-Q-0012	Filter - Separator - Coalescer Sizing
530-EDP-Q-0013	2 Phase Sep, KO Drum Sizing
ATP-EDP-Q-0015	Fuel Gas Heater Sizing
ATP-EDP-Q-0020	Heat Exchanger and ACHEs
ATP-EDP-Q-0023	Utilities Design
ATP-EDP-HSE-0001	Emissions Control [Ref.4]

Plant piping shall be sized and designed consistent with the Line Sizing Guide, [Ref.6] and the Piping Design Criteria, [Ref.17].

All fluid contacting materials shall be compatible with the Process Fluids, [Ref.10], and their anticipated contaminants (e.g., BTEX, mercury) for the design service life.

The recently identified phenomenon of “elemental sulphur” deposition in pipelines is discussed in the Sulphur Deposition, [Ref.11]. This is primarily a maintenance and instrument reliability concern rather than process design.

4. DESIGN DOCUMENTATION

Inherently Safer Design, [Ref.12], establishes the requirement for several high-level design and operation philosophies and process narratives. These shall be used to establish the primary facility requirements.

Emissions Control, [Ref.4], establishes the requirement for several high-level design and operation philosophies and process used to reduce GHG emissions.

The facility environmental data shall be recorded consistent with the Process Design Specification, [Ref.22].

Facility process drawings and equipment identification numbering shall be consistent with the PFD, P&ID and PSC Design, [Ref.18] and the Identification of Lines, Valves, Equipment, Electrical, Instruments & Cables Tag Numbers, [Ref.19].

PFDs shall provide a high-level view of the process as a whole and be accompanied by heat and mass balance tables. The PFD should only include equipment that is core to the process and avoid any extraneous details such as minor valves, instrumentation, and utility systems.

P&IDs shall provide information of all installed piping, instrumentation, and equipment. They are the core process document set and are the overall representation of the plant. It is preferred to capture as much detail as possible of the plant operation and control logic on the P&IDs themselves. Other documents such as Cause and Effect Charts and Process Safety Diagrams (PSDs) shall be used as necessary where representation on the P&IDs is not suitable due to the complexity. These supporting documents are always secondary to the P&IDs.

4.1 Design Calculations

All facility design calculations shall be developed using the Calculation Coversheet, [Ref.20] to record the design inputs and results. Major design inputs, assumptions and conclusions shall be recorded on the coversheet. Each design calculation shall be written with sufficient context and detail so that a qualified process engineer who has otherwise no experience with the facility can understand the calculation.

Common design element calculation templates have been produced to provide a consistent output, (also listed in [Appendix A]):

Table 10 Design element calculation templates

Doc. Number	Doc. Name
530-TP-Q-0008	HMB Template
530-TP-Q-0014	Regulator & Control Valve Sizing
530-TP-Q-0015	PSV Sizing
530-TP-Q-0016	AS 2885.1 Pipeline Rupture Radiation
530-TP-Q-0017	Line Pack
530-TP-Q-0027	Pump Sizing
530-TP-Q-0032	API 521 Flare / Vent Radiation
530-TP-Q-0033	2-Phase Separator / KO Drum Calculation

When used, these shall be attached to the design calculation which provides the necessary context for the inputs.

4.2 Process Modelling

Where process thermodynamic modelling is required for a calculation, either Aspen HYSYS or NIST REFPROP should be used. Other thermodynamic programs are acceptable provided they have been validated over the range of process conditions used. HYSYS SS / Dynamic Simulation, [Ref.9], provides guidance on the use of HYSYS. HYSYS templates are available and listed in Appendix A.

REFPROP functions are available for calculation through Microsoft Excel. See 0 - Appendix E.

4.3 Process Safety Risk Mitigation & Risk Studies

The following documents provide direction on strategies to identify and eliminate or mitigate process safety risks, (also listed in [Appendix A]):

Table 11 Documents to identify and eliminate or mitigate process safety risks

Doc. Number	Doc. Name
530-EDP-R-0001	Inherently Safer Design [Ref.12]
530-EDP-R-0002	Facility Layout and Spacing
530-EDP-R-0003	Fire & Explosion Risk Studies
530-EDP-R-0004	Fire Protection
530-EDP-J-0003	Fire & Gas Detection and Monitoring Equipment
530-PHL-R-0001	Fire and Gas Philosophy

5. REVISION CHANGE RECORD

Table 12 Revision Change Record

Rev	Description	Date	Author
1	Document content based on 530-EDP-Q-0028 Rev 1 and updated as appropriate. Net Zero and environmental considerations added.	23.06.2023	C. Nicholson

6. TERMS

ITEM	[2]DEFINITION
Active safety	This strategy involves alarms, interlocks and mitigation systems designed to detect an unsafe condition and put the system into a safe state, usually either by taking emergency action to return the system to normal operating conditions or by shutting it down. Active systems may be designed to prevent an accident or to minimise the consequences of an accident. In the context of facility design, this involves safety systems (fire and gas, emergency shutdown) and process control systems.
Charpy impact test	A standardised high strain rate test which determines the amount of energy absorbed by a material during fracture.
Greenhouse Gas	A Greenhouse Gas (GHG) is a gas that absorbs and emits radiant energy within the thermal infrared range, causing the greenhouse effect. The primary Greenhouse gases in Earth's atmosphere are water vapor (H_2O), carbon dioxide (CO2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3).
HYSYS	A chemical process simulator software, developed by AspenTech used to mathematically model chemical processes.
Inherently safer design (ISD)	A process safety management strategy that aims to permanently eliminate or reduce hazards to avoid or reduce the consequences of incidents.
JT cooling effect	The real gas phenomenon where the temperature cools when the gas pressure is reduced at constant enthalpy.
Net Zero	A target of completely negating the amount of greenhouse gases produced by human activity, to be achieved by reducing emissions and implementing methods of absorbing carbon dioxide from the atmosphere.
Norsk Sokkels Konkurranseposisjon	The Norwegian Continental Shelf's Competitive Position, the NORSOK Standards are standards for the oil and gas industry.
Passive safety	This strategy involves process or equipment design features that control or mitigate the consequences associated with a hazard without requiring active functioning of any device.

[2] Definitions should be accompanied by a reference using the "Citations & Bibliography" APA style. Terms listed in the APA Engineering Glossary need not be repeated in this list.

Procedural safety	This strategy involves standard operating procedures, operator training, emergency response procedures, safety checklists and other management systems dependent on people.
Do Not Exceed Limit	The upper or lower limit that must not be exceeded during either normal (steady state) or transient operation as established by applicable codes and standards.
Major Accident Event	Any incident resulting in any of the following: • Serious personal injury or fatality • Serious environmental effects, including impairment of ecosystem function • Ongoing significant social issues Significant adverse attention from external parties or loss of licence to operate.
Normal Operating Limit (NOL)	The limit that should not be exceeded during normal (steady state) operation.
Possible Operating Envelope	The operating range that may be feasibly experienced by the installed plant, including due to failures of either upstream or downstream equipment, controls, or layers of protection. This is typically wider than the Normal Operating Envelope.
Safe Operating Limit (SOL)	The point at which operational trouble shooting ceases and immediate predetermined actions are taken to bring the process back to a safe state.

7. [3]ABBREVIATIONS

ITEM	DEFINITION
ACHE	Air-Cooled Heat Exchanger
BPG	Best Practice Guide
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
DNL	Do Not Exceed Limit
EDP	Engineering Design Practice
GHG	Greenhouse Gas
HAZOP	Hazard and Operability
ISD	Inherently Safe Design
JT	Joule-Thomson
LOPA	Layers of Protection Analysis
MGP	Methane Guiding Principles
NIST	National Institute of Standards and Technology
NOL	Normal Operating Limit
NORSOK	Norsk Sokkels Konkurranseposisjon
P&ID	Piping and Instrumentation Diagram
PFD	Process Flow Diagram
PSC	People, Safety and Culture
PSD	Process Safety Diagram
PSV	Pressure Safety Valve
REFPROP	Reference Fluid Thermodynamic and Transport Properties Database
SOL	Safe Operating Limits
SOLR	Safe Operating Limit Register
TP	Template

[3] Any abbreviation (acronym) used more than once in the body of the document shall be listed in this table. An abbreviation/acronym used once only, must be written out in full in parentheses after the abbreviation/acronym, for example WIP (Work in Progress).

8. REFERENCES

All work performed in accordance with this document shall be in conformance with the current issue, including amendments, of those national and international standards, codes of practice, guidelines and APA document/s listed below.

APA STANDARDS

Ref. No.	DOC NO.	DESCRIPTION
1.	530-LI-QM-0001	APA Engineering Glossary
2.	530-PR-EM-0002	Engineering Standards Waivers
3.	530-PR-EM-0003	APA Engineering Standards (Development and Application)
4.	ATP-EDP-HSE-0001	Emissions Control (to be released Oct 20203)
5.	530-EDP-Q-0001	Sizing and Selection of Relief Devices
6.	530-EDP-Q-0002	Line Sizing Guide
7.	ATP-EDP-Q-0003	Flares and Vents
8.	530-EDP-Q-0006	Overpressure Protection Philosophy
9.	530-EDP-Q-0010	HYSYS SS / Dynamic Simulation
10.	ATP-EDP-Q-0017	Process Fluids
11.	530-EDP-Q-0027	Sulphur Deposition
12.	530-EDP-R-0001	Inherently Safer Design
13.	530-GD-Q-0005	Managing MAOP & MOP Limitations for AS2885 Pipelines
14.	530-PHL-Z-0001	Alarm Philosophy
15.	530-PL-FS-0001	Functional Safety Management Plan
16.	530-PR-Z-0003	Alarm Design Procedure
17.	530-SP-P-0001	Piping Design Criteria
18.	530-SP-Q-0002	PFD, P&ID, and PSC Design
19.	530-SP-Q-0003	Identification of Lines, Valves, Equipment, Electrical, Instruments & Cables Tag Numbers
20.	530-TP-Q-0003	Calculation Coversheet
21.	530-TP-Q-0034	Safe Operating Limits Register Engineering Template
22.	ATP-TP-Q-0036	Process Design Specification
23.	APA Group Standard	Climate Change Standard

24.	APA Group Procedure	Internal Carbon Pricing
SUPERCEDED DOCUMENTS		
Ref. No.	DOC NO.	DESCRIPTION
	530-EDP-Q-0028	Process Design Guideline, Rev 2
AUSTRALIAN STANDARDS		
Ref. No.	DOC NO.	DESCRIPTION
25.	AS 1210	Pressure Vessels
26.	AS 1692	Steel tanks for flammable and combustible liquids
INTERNATIONAL STANDARDS		
Ref. No.	DOC NO.	DESCRIPTION
27.	NORSOK P-002	Norsk Sokkels Konkurranseposisjon, *Process System Design*, 2023
28.	ASME B31.3	American Society of Mechanical Engineers Standard, *Process Piping Code*
29.	ASME VIII	American Society of Mechanical Engineers Standard, *Boiler & Pressure Vessel Code (BPVC)*
30.	API 520	American Petroleum Institute Standard 520,
31.	API 521	American Petroleum Institute Standard 521,
32.	API 650	American Petroleum Institute Standard 650, *Welded Tanks for Oil Storage*, 13th ed.
OTHER		
Ref. No.	DOC NO.	DESCRIPTION
33.	Methane Guiding Principles	The Methane Guiding Principles

9. LISTS

9.1 Tables

9.2 Figures

APPENDIX A APA STANDARDS

The following is a list of available process related APA standards including Process(Q), risk R, functional safety (FS), piping(P).

APA Standard		Description	Ref.
530-EDP-J-0003	Fire & Gas Detection and Monitoring Equipment	Describes the designs of fire, gas, heat, and smoke detection systems.	[Table 11]
ATP-EDP-HSE-0001	Emission Control	Guidance and requirements for controlling and reduction of GHG emissions.	[Ref.4]
530-EDP-Q-0001	Sizing and Selection of Relief Devices	The sizing and selection of relief devices for process plant, piping, or pipelines. Additionally provides interpretation on API 520, [Ref.30], API 521, [Ref.31], and AS 1210 [Ref.25] for overpressure protection.	[Ref.5] [Table 2]
530-EDP-Q-0002	Line Sizing Guide	Hydraulic analysis and pipe sizing for gas, liquid and two-phase piping as commonly encountered in process plants including vent piping.	[Ref.6]
ATP-EDP-Q-0003	Flares and Vents	The sizing and selection of flares and vents as well as temporary pipeline vents. Additional requirements for air ingress protection, liquid knockout, noise, dispersion, and radiation limits are also discussed.	[Ref.7] [Table 2] [Table 5]
ATP-EDP-Q-0004	Process Input into Pipeline Isolation Plans	Required process input to pipeline isolation plans. Pipeline isolation and blowdown and the related risks are the primary considerations.	[Table 2]
530-EDP-Q-0005	Plume Dispersion and Radiation	Requirements for gas dispersion and radiation analysis from flares and vents.	[Table 2]
530-EDP-Q-0006	Overpressure Protection Philosophy	Guidance on the selection of system of design pressures and an overview of the overpressure protection controls available and preferences for their usage in relevant scenarios.	[Ref.8] [Table 2]
530-EDP-Q-0008	Ignition Control	Description of ignition sources and their relevant controls. This is related to hazardous area analysis.	[Table 2]
530-EDP-Q-0010	HYSYS SS and Dynamic Models	Guidance on the use of Aspen HYSYS for the development of process simulation models and the preparation of heat and mass balance tables.	[Ref.9]
530-EDP-Q-0011	Generic Compressor Station Process Design Specification	Template for a specification for a proposed compressor station.	[Table 9]
530-EDP-Q-0012	Filter / Separator / Coalescer Sizing	Selection of filters and separators for mostly clean gases.	[Table 5] [Table 9]
530-EDP-Q-0013	2 and 3-Phase Separator Sizing	Sizing and selection of two and three phase separators. Different separation technologies and their sizing equations are discussed.	[Table 5] [Table 9]
ATP-EDP-Q-0015	Fuel Gas Heater Sizing	Sizing and selection of fuel gas heaters and discussion of fuel gas specification requirements. Discussion of the relative merits of different heater technologies.	[Table 9]
ATP-EDP-Q-0017	Process Fluids	Description of commonly encountered classes of fluids throughout APA.	[Ref.10]

APA Standard		Description	Ref.
ATP-EDP-Q-0019	Gas Breakthrough and RO Sizing – Liquid Lines	Design consideration for liquid drain lines, particularly overpressure and minimum temperature design considerations.	[Table 5]
ATP-EDP-Q-0020	Heat Exchangers and ACHEs	Sizing and selection of heat exchangers including air cooled heat exchangers. Presents heat exchange theory and equations as well as typical applications of heat exchangers.	[Table 5] [Table 9]
530-EDP-Q-0021	PFD & P&ID Preparation / Design	Guidance for the requirements of process drawings: BFDs, PFDs, UFDs, PSSs, P&IDs, and PSCs. Also describes the interdisciplinary responsibilities of	
ATP-EDP-Q-0023	Utilities Design	Description of commonly encountered utility systems: Air, Nitrogen, Instrument Gas, Fuel Gas, Hot Oil, Hot Water, Lube Oil, Sampling, Chemical Injection, Cooling Water, Fire Water, Wastewater, Electrical, Cleaning.	[Table 9]
530-EDP-Q-0025	Facilities Shutdown	Describes requirements for design and documentation of shutdown systems for compressor stations and other complex facilities.	[Table 2]
530-EDP-Q-0027	Sulphur Deposition	Describes the phenomena of elemental sulphur and black powder deposition in pipelines. Also describes management and mitigation techniques.	[Ref.11]
530-EDP-R-0001	Inherently Safer Design	Guidance on the requirements for demonstrating and documenting the various processes to implement an inherently safer design throughout all stages of Engineering Design. Applies to onshore facilities including compressor stations, pressure reduction stations, odorising stations, underground gas storage facilities, metering stations, gas plants (including LNG facilities) as well as gas transmission pipelines.	[Ref.12] [Table 11]
530-EDP-R-0002	Facility Layout and Spacing	Guidance on the requirements for layout of new facilities. In particular, the minimum spacing requirements between classes of buildings and process equipment.	[Table 11]
530-EDP-R-0003	Fire & Explosion Risk Studies	Defines the requirements for Fire and Explosion Risk Analysis and Fire Safety Studies. Also discusses hazard and risk minimisation techniques.	[Table 11]
530-EDP-R-0004	Fire Protection	Discusses the design of active fire protection systems such as Fire Water, Foam, Mist and Gaseous protection systems. In addition, passive fire protection such as dampers, doors, walls and insulation.	[Table 11]
530-EDP-R-0006	Process Safety and Safeguarding	Guidance of the requirements for demonstrating and documenting the implementation of process safety and process safeguarding, including Process Safeguarding Narratives and Schematics	
530-GD-Q-0004	Process Isolation Philosophy	Defines the requirement for isolation valving (and other isolation techniques such as spades, blinds and removable spools) in facilities and provides typical illustrations of valve assemblies.	

APA Standard		Description	Ref.
530-GD-Q-0005	Managing MAOP & MOP Limitations	The document provides a framework for settings around maximum operating pressures and guides users to the Alarm Configuration Standard for setting layers of protection around pressure sources when revising an assets maximum operating pressure.	
530-GD-Q-0006	Maximum Operating Pressure Change – Stakeholders and Change Process	Defines the required actions for initiation and control of Maximum Operating Pressure (MOP) changes for pipelines.	
530-LI-QM-0001	Engineering Glossary	Glossary of terms used	[Ref.1]
530-PHL-R-0001	Fire and Gas Philosophy	Outlines a complete approach to control and prevention of fire on APA facilities through the detection and control of fire and gas releases	[Table 11]
530-PL-FS-0001	Functional Safety Management Plan	Details APA requirements for documenting and ensuring the functional safety of equipment is maintained throughout the facility lifecycle. It addresses the requirements of AS IEC 61511.	[Ref.15]
530-SP-P-0001	Piping Design	Design requirements for station piping (not pipelines).	[Ref.17]
530-SP-Q-0003	Identification of Lines, Valves, Equipment, Electrical, Instruments & Cables Tag Numbers	Defines the standard for numbering of lines, valves and equipment and the representation on drawings.	[Ref.19]
530-TP-Q-0002	Process Equipment List	Lists process equipment in a facility according to its tag number and associated reference documents.	
530-TP-Q-0003	Calculation Coversheet	Template for use in preparing engineering calculations.	[Ref.20]
530-TP-Q-0004	Process Line List	Line list for process facilities. This template should not be used manually. Generated by smart tools. Contact design office.	
530-TP-Q-0008	HMB Template	Standard presentation format for heat and mass balances. Two sheets available for variable or constant composition. Designed to be compatible with the HMB produced from HYSYS.	[Table 10]
530-TP-Q-0009	Restriction Orifice Sizing	Sizing of square edged restriction orifices in gas service. Suitable for critical or sub-critical flow.	
530-TP-Q-0014	Regulator & Control Valve Sizing	Sizing estimation for control valve in gas, liquid and two-phase flow. Also contains noise estimation for control valves in gas service.	[Table 10]
530-TP-Q-0015	PSV Sizing	Sizing estimation for conventional, balanced and pilot operated PSVs in accordance with API 520, [Ref.30]. Includes calculations for the effects of backpressure. Also includes relief rate estimation for fire cases per API 521, [Ref.31].	[Table 10]
530-TP-Q-0016	AS 2885.1 Pipeline Rupture Radiation	Rupture rate and radiation exclusion zone calculation for use with full-bore pipeline rupture scenarios per AS 2885.1.	[Table 10]
530-TP-Q-0017	Line Pack	Estimation of total line pack in pipelines with consideration for elevation changes.	[Table 10]

APA Standard		Description	Ref.
530-TP-Q-0020	HYSYS: Regulator station	This model considers a regulator valve and heater. The heater duty is calculated based on achieving a required outlet temperature.	
530-TP-Q-0021	Data Sheet – Gas Composition	Calculates common gas properties including a phase diagram for a given composition.	
530-TP-Q-0022	HYSYS: Pipeline	This model serves as a starting point for a pipeline model. Pipeline configuration and elevation changes should be input to match the system.	
530-TP-Q-0023	HYSYS: Compressor Station	This compressor station model considers a compressor and air-cooler, one model with, and one without recycle. For convenience, a model excluding recycle is also available. Additional pressure losses in the model can be added with the included valves.	
530-TP-Q-0024	HYSYS: Vessel Blowdown	This model considers the blowdown of a single vessel using HYSYS' BLOWDOWN module which is based on empirical blowdown studies. Vessel and attached piping sections are modelled and should be defined using realistic values.	
530-TP-Q-0025	HYSYS: Pipeline Blowdown	This model determines the expected temperatures and duration of a pipeline blowdown. It considers heat transfer to the gas from the surrounding environment and has been calibrated against field data.	
530-TP-Q-0026	HYSYS: Detailed Air-Cooled Exchanger	This model is similar to the Compressor Station model except the air-cooler has been rated in Aspen EDR (using the auto-sizing utility). This can be adjusted as required to suit the scenario in question using the Rigorous Air Cooler tab.	
530-TP-Q-0027	Pump Sizing	Determines sizing for a centrifugal pump and electric motor including efficiency estimation. Performs additional checks for NPSH adequacy.	[Table 10]
530-TP-Q-0028	Hydraulic Calculations	Calculates hydraulic loses in plant piping including fittings.	
530-TP-Q-0029	HYSYS: PSV Tailpipe	This model calculates a PSV back pressure for a given input flow, solving for Mach 1 as calculated in the spreadsheet unit operation. It also calculates inlet and outlet piping pressure drops.	
530-TP-Q-0030	HYSYS: Detailed Compressor and ACHE	This compressor and cooler model calculates the compressor discharge pressure based on gas flow rate and inlet pressure onto a characterised compressor wheel map. It also includes a characterisation of the (gas turbine) driver available power as a function of both ambient temperature and turbine speed which is used to limit the discharge pressure.	
530-TP-Q-0031	HYSYS: Dew Points	This model calculates the dew point of the gas and allows the user to saturate the gas stream with the required water concentration on any required unit's basis. By default, the streams are calculated on a mg/Sm³ basis.	

APA Standard		Description	Ref.
530-TP-Q-0032	API 521 Flare / Vent Radiation	Estimates the effective radiation from an ignited flare / vent using the methodology given in API 521, [Ref.31].	[Table 10]
530-TP-Q-0033	2 Phase Separator / KO Drum Calculation	Sizing calculation of two-phase separators in either horizontal or vertical configuration. Considers gravity separation or mesh pad / vane pack separation using the K factor method. Also calculates the minimum required liquid control heights based on a minimum height and minimum residence times.	[Table 10]
530-TP-Q-0035	Generic Compressor Station Process Design Specification	To be used as a starting point for new compressor stations.	
ATP-TP-Q-0036	Process Design Specification	Describes process design inputs for Design Basis Memoranda and Process Design Specifications.	[Ref.22]
530-WI-Q-0001	PFDs, P&IDs, and PSCs Symbols	Lists symbols used for process drawings and their descriptions.	

APPENDIX B PROCESS DOCUMENT DIAGRAM

The following diagram presents the ATP/530[4]-series process documents in a structured diagram. The arrows represent that a document depends on another or that a document is an implementation of the principles given in another.

The natural groupings of documents represent a set of documents that should be used in conjunction to produce a design.

[4] The 530 series is currently being replaced with ATP. Documents that have been updated follow the standard superseding and referencing process, for maximum clarity.

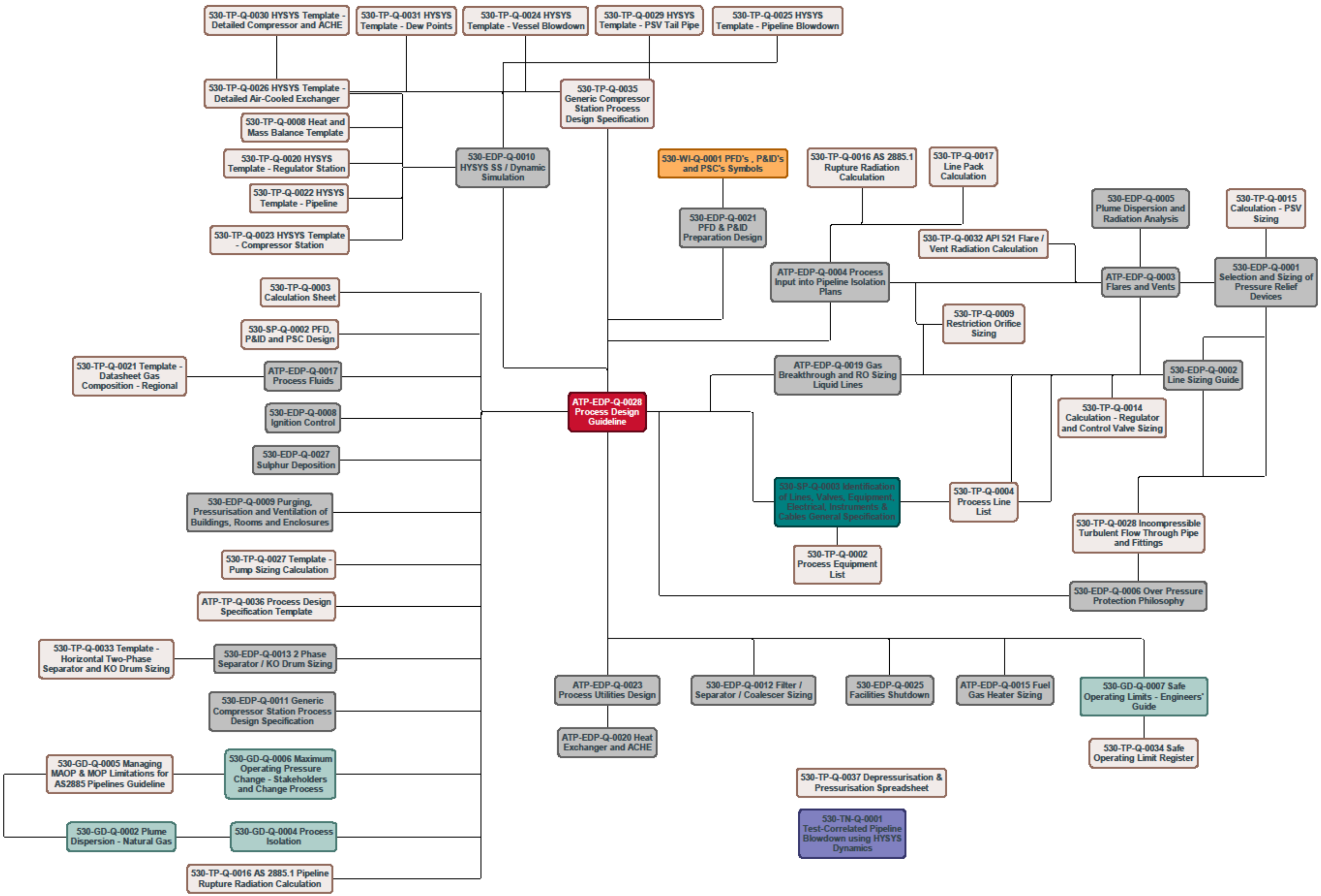
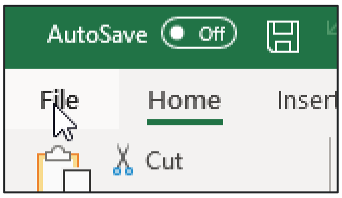


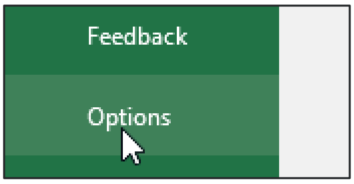
Figure 2 APA Standards Process Document Diagram!

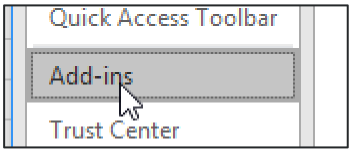
APPENDIX C REFPROP – EXCEL EXTENSION

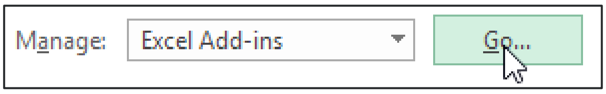
The REFPROP extension functions can be installed to Excel via the following steps:

1. Open Excel and go to the Add-In manager via:

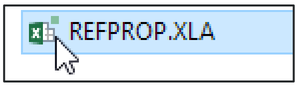






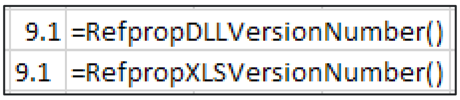


2. Click browse, go to the REFPROP installation folder and select REFPROP.XLA file:



3. Ensure that the Add-In is enabled:

4. Once enabled, the REFPROP version and Excel Add-In version number can be calculated from the following functions:



APPENDIX D REFPROP - STANDARD UNITS

The units expected and produced by REFPROP can be seen by the function:

Table 13 Function PropertyUnits(InpCode, Units)

Units / InpCode	SI	SI with C	Molar SI	Mixed	E	Molar E	cgs	mks
"T" Temperature	K	C	K	K	F	F	K	K
"P" Pressure	MPa	MPa	MPa	psia	psia	psia	MPa	kPa
"D" Density	kg/m^3	kg/m^3	mol/dm^3	g/cm^3	lbm/ft^3	$lbmol/ft^3$	g/cm^3	kg/m^3
"V" Volume	m^3/kg	m^3/kg	dm^3/mol	cm^3/g	ft^3/lbm	$ft^3/lbmol$	cm^3/g	m^3/kg
"H" Enthalpy	kJ/kg	kJ/kg	J/mol	J/g	Btu/lbm	Btu/lbmol	J/g	kJ/kg
"E" Internal Energy	kJ/kg	kJ/kg	J/mol	J/g	Btu/lbm	Btu/lbmol	J/g	kJ/kg
"S" Entropy	kJ/kg-K	kJ/kg-K	J/mol-K	J/g-K	Btu/lbm-R	Btu/lbmol-R	J/g-K	kJ/kg-K
"W" Speed of Sound	m/s	m/s	m/s	m/s	ft/s	ft/s	cm/s	m/s
"U" Viscosity	uPa-s	uPa-s	uPa-s	uPa-s	lbm/ft-s	lbm/ft-s	uPa-s	uPa-s
"K" Thermal Conductivity	mW/m-K	mW/m-K	mW/m-K	mW/m-K	Btu/h-ft-F	Btu/h-ft-F	mW/m-K	W/m-K
"N" Surface Tension	mN/m	mN/m	mN/m	mN/m	lbf/ft	lbf/ft	dyn/cm	mN/m
"Z" Compressibility	-	-	-	-	-	-	-	-
"B" Volume	m^3/kg	m^3/kg	dm^3/mol	cm^3/g	ft^3/lbm	$ft^3/lbmol$	cm^3/g	m^3/kg

APPENDIX E REFPROP - COMMON FUNCTIONS

Most REFPROP functions take the form:

```
Name:       (FluidName, InpCode, Units, Prop1, Prop2)
```

where

FluidName = text, fluid must be either in Fluids or Mixtures sub directories.

InpCode = name and order of Prop1 and Prop2.

"TP" would mean Prop1 is Temperature, Prop2 is Pressure (need quotes)

Valid InpCodes: TP,TD,TH,TS,TE,TQ,PD,PH,PS,PE,PQ,DH,DS,DE,HS

To define saturated liquid or vapor inputs: TLIQ, TVAP, PLIQ, PVAP

Other: Crit, Trip, TMelt, PMelt, TSubl, PSubl

The word "Optional" appears in the argument listings below to indicate that PROP2 is not always required depending on the InpCode argument.

In some cases, PROP1 is also optional.

Units = "SI", "SI with C" (or just "C"), "Molar SI", "E", "molar E", "cgs", "mks", "Mixed" (need quotes). "SI" is used by default if no input is given. (Unless DefaultUnits changed in VBA code)

Prop1 = numerical value of the first input property (in the units of the previous line)

Prop2 = numerical value of the second input property (if required).

The following functions are frequently used:

```
Function Temperature            (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Pressure               (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Density                (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function CompressibilityFactor (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Enthalpy               (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Entropy                (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Cv                     (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Cp                     (FluidName, InpCode, Units, Prop1, Optional Prop2)
Function Quality                (FluidName, InpCode, Units, Prop1, Optional Prop2)
```

The fluid string functions can be used to specify arbitrary compositions as supplied to the Names and Comps arguments. The inputs are assumed to be mole fractions unless “mass” is given in the mass-mole argument.

```
Function FluidString          (Names, Comps, Optional massmole As String)
```

When a fluid is in a two-phase condition, the composition of each phase can be obtained from:

```
Function LiquidFluidString      (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2)

Function VaporFluidString       (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2)
```

Note that after using Liquid or Vapour fluid strings it may be the case where the subsequent property calculations are just inside the two-phase boundary resulting in errors in calculation. This can be solved by adding (for vapour) or removing (for liquid) a small temperature value (i.e., 0.000001 °C) to force the fluid into the correct phase or using the explicit TLIQ, TVAP, PLIQ, PVAP input codes.

The complete function listing is shown in Appendix F. Additional functionality is available by accessing the REFPROP.dll directly. Details of the use of the dll and the default executable can be seen in the user manual, typically located in “C:\Program Files (x86)\REFPROP\REFPRP91.PDF”.

APPENDIX F REFPROP FULL FUNCTION LISTING

```
'REFPROP Excel Functions
'Arguments:  (FluidName, InpCode, Units, Prop1, Prop2)
'FluidName = text,  fluid must be either in Fluids or Mixtures sub directories.
'InpCode   = name and order of Prop1 and Prop2.
'            "TP" would mean Prop1 is Temperature, Prop2 is Pressure (need quotes)
'            Valid InpCodes:  TP,TD,TH,TS,TE,TQ,PD,PH,PS,PE,PQ,DH,DS,DE,HS
'            To define saturated liquid or vapor inputs:  TLIQ, TVAP, PLIQ, PVAP
'            Other:  Crit, Trip, TMelt, PMelt, TSubl, PSubl
'
'            The word "Optional" appears in the argument listings below to indicate that
'            PROP2 is not always required depending on the InpCode argument.
'            In some cases, PROP1 is also optional.
'
'Units      = "SI", "SI with C" (or just "C"), "Molar SI", "E", "molar E", "cgs", "mks", "Mixed" (need
quotes).  "SI" is used by default if no input is given. (Unless DefaultUnits changed in VBA code)
'Prop1     = numerical value of the first input property (in the units of the previous line)
'Prop2     = numerical value of the second input property (if required).


'Function Temperature           (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Pressure              (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Density               (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function LiquidDensity         (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function VaporDensity          (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Volume                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function CompressibilityFactor (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Energy                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Enthalpy              (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function LiquidEnthalpy        (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function VaporEnthalpy         (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Entropy               (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsochoricHeatCapacity (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Cv                    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsobaricHeatCapacity  (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Cp                    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function SpecificHeatInput     (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Csat                  (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function SpeedOfSound          (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Sound                 (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dPdrho                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function d2Pdrho2              (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dPdT                  (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dPdTsat               (FluidName, InpCode, Units, Prop1, Optional Prop2)
```

```
'Function drhodT                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdT_D                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdT_P                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdD_T                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdD_P                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdP_T                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function dHdP_D                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Cstar                 (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Quality               (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function QualityMole           (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function QualityMass           (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function LatentHeat            (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function HeatOfVaporization    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function HeatOfCombustion      (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function GrossHeatingValue     (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function NetHeatingValue       (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function JouleThomson          (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsentropicExpansionCoef       (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsothermalCompressibility     (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function VolumeExpansivity             (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function AdiabaticCompressibility      (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function AdiabaticBulkModulus          (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsothermalExpansionCoef       (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function IsothermalBulkModulus         (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function SecondVirial          (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Viscosity             (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function KinematicViscosity    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function ThermalConductivity   (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function ThermalDiffusivity    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function Prandtl               (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function SurfaceTension        (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function DielectricConstant    (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function MolarMass             (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function EOSMax                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function EOSMin                (FluidName, InpCode, Units, Prop1, Optional Prop2)
'Function LiquidFluidString     (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional
Prop2)
'Function VaporFluidString      (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional
Prop2)
'Function FluidString           (Nmes, Comps, Optional massmole As String)
'Function PropertyUnits         (InpCode, Units)

'In the following, i is the component number in the mixture (where the maximum value of i can be 20)
```

```
'Function ComponentName          (FluidName, i)
'Function MoleFraction           (FluidName, i)
'Function MassFraction           (FluidName, i)
'Function LiquidMoleFraction     (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function VaporMoleFraction      (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function LiquidMassFraction     (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function VaporMassFraction      (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function Activity               (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function ActivityCoefficient    (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function ChemicalPotential      (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function Fugacity               (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function FugacityCoefficient    (FluidName, Optional InpCode, Optional Units, Optional Prop1, Optional Prop2, Optional i)
'Function Mole2Mass              (FluidName, i, Prop1, Prop2, Optional Prop3, Optional Prop4, Optional Prop5, Optional Prop6, Optional Prop7, Optional Prop8, Optional Prop9, Optional Prop10, Optional Prop11, Optional Prop12, Optional Prop13, Optional Prop14, Optional Prop15, Optional Prop16, Optional Prop17, Optional Prop18, Optional Prop19, Optional Prop20)
'Function Mass2Mole              (FluidName, i, Prop1, Prop2, Optional Prop3, Optional Prop4, Optional Prop5, Optional Prop6, Optional Prop7, Optional Prop8, Optional Prop9, Optional Prop10, Optional Prop11, Optional Prop12, Optional Prop13, Optional Prop14, Optional Prop15, Optional Prop16, Optional Prop17, Optional Prop18, Optional Prop19, Optional Prop20)


'The following functions are for Document Reference
'Function WorkBookName
'Function RefpropXLSVersionNumber
'Function RefpropDLLVersionNumber
'Function WhereAreREFPROPfunctions
'Function WhereIsWorkbook
'Function SeeFileLinkSources
'Function SelectedDefaultUnits
```