



Data Exchange in
the Process Industry

DEXPI and IDO

2024-09-13, 13:00 – 14:30

Gregor Tolksdorf, Evonik, Head of DEXPI Specifications
Heiner Temmen, DEXPI e.V., DEXPI Networking

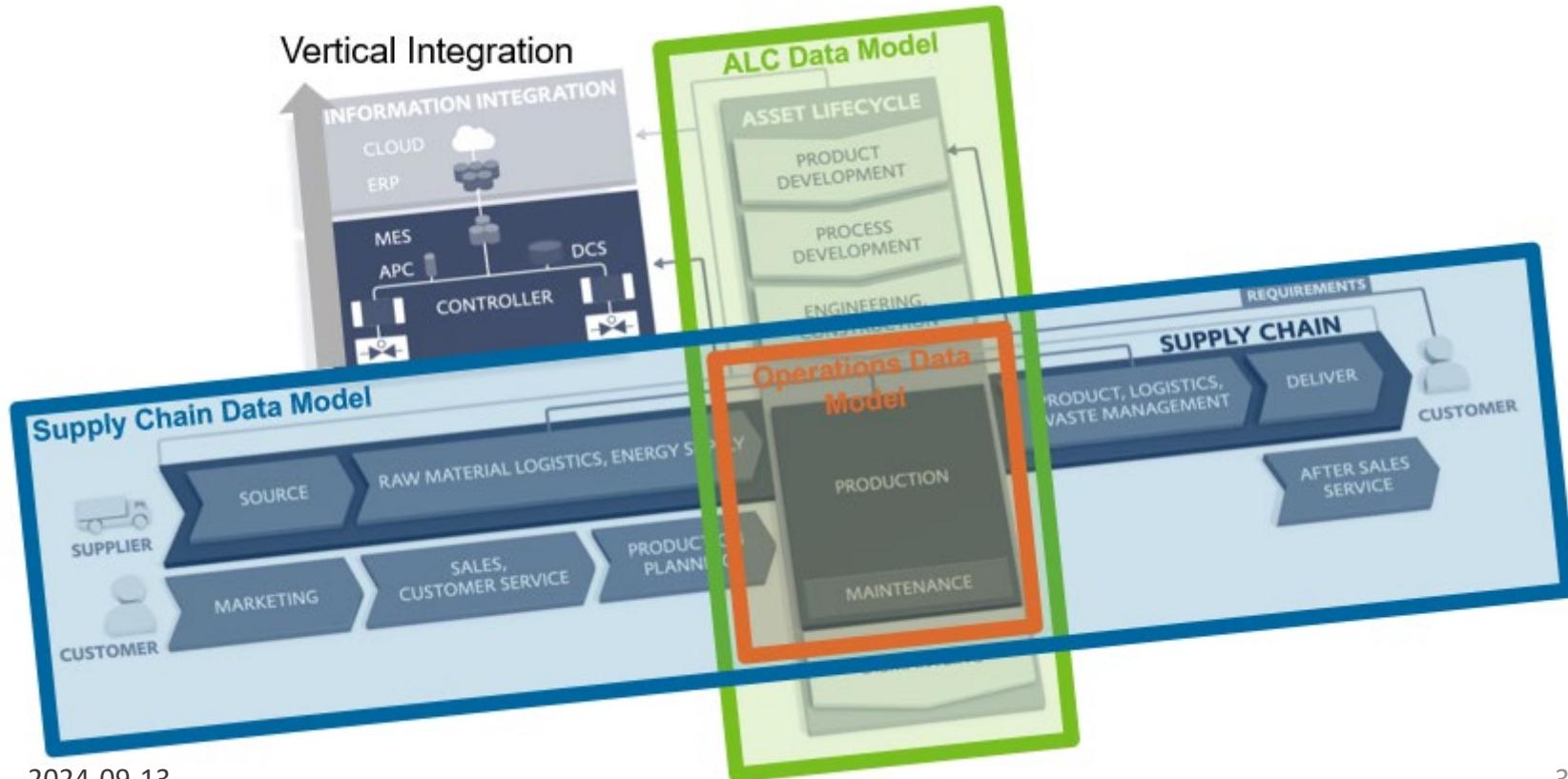


DEXPI

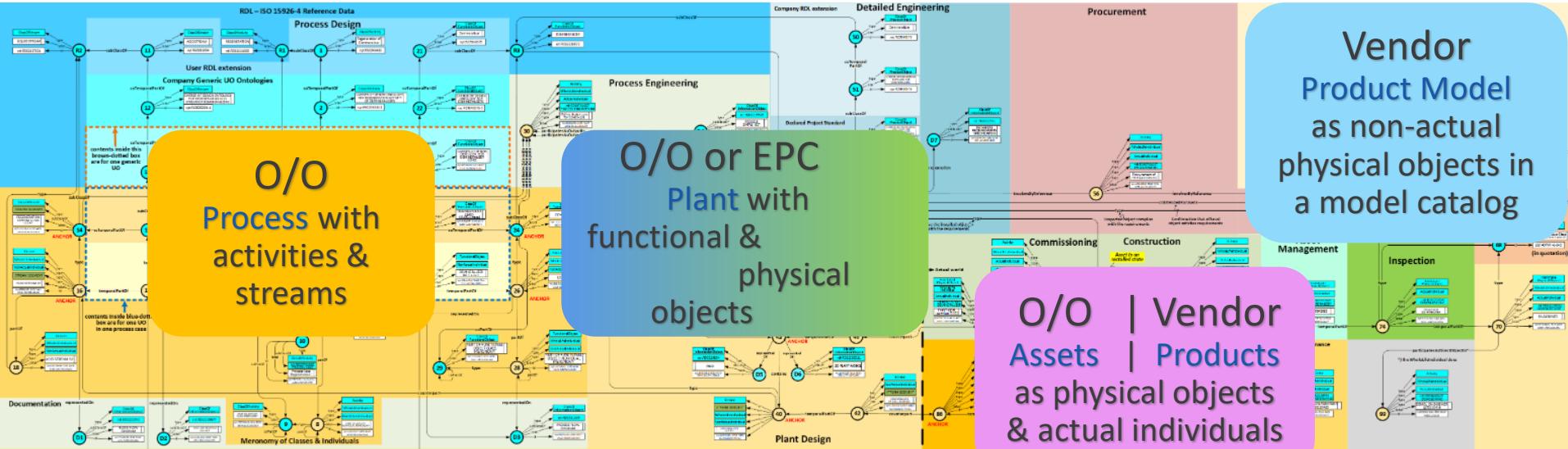
Data Exchange in
the Process Industry

- Common view on the plant life cycle of the Process Industry
- DEXPI Plant (=P&I D)
- DEXPI Process (=BFD & PFD)
- DEXPI and IDO
- DEXPI as aligned part of process industry solutions, example CFIHOS

Supply chain and asset life cycle of the process industry



ISO 15926 Plant Life cycle model with pump example



PUMPING
as a process step

PUMP and CENTRIFUGAL
PUMP
as a plant object

A CENTRIFUGAL PUMP
as an installed object

CENTRIFUGAL PUMPs,
which can be bought

DEXPI Mission

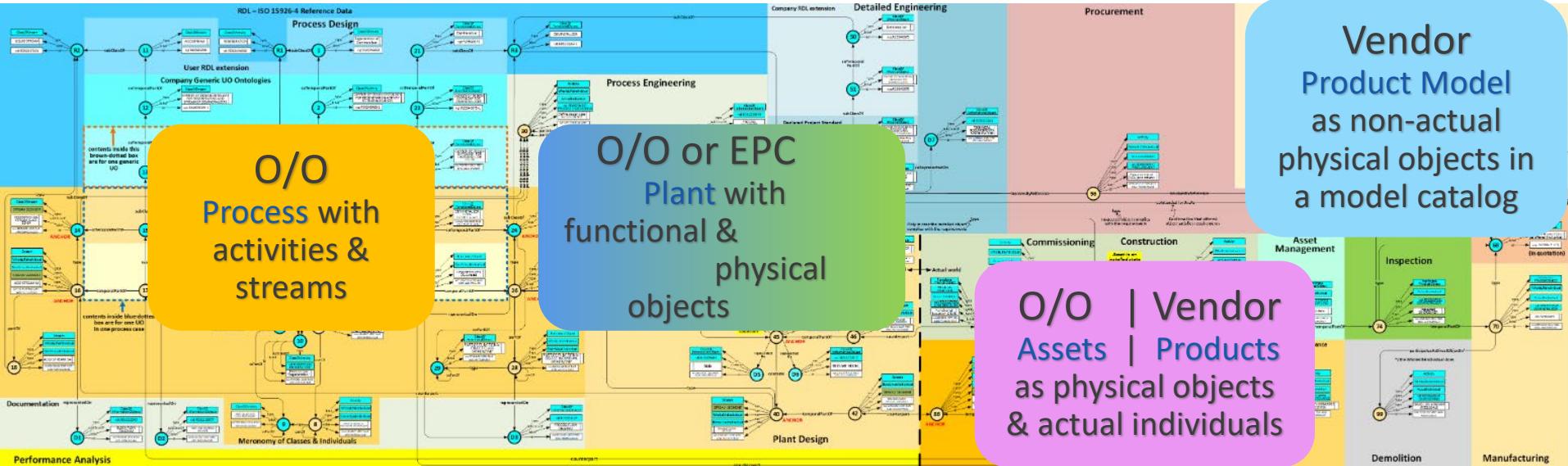


We develop and promote a common data exchange standard for the process industry, covering all phases of the process-plant life cycle, from the specification of functional requirements to the assets in operation.

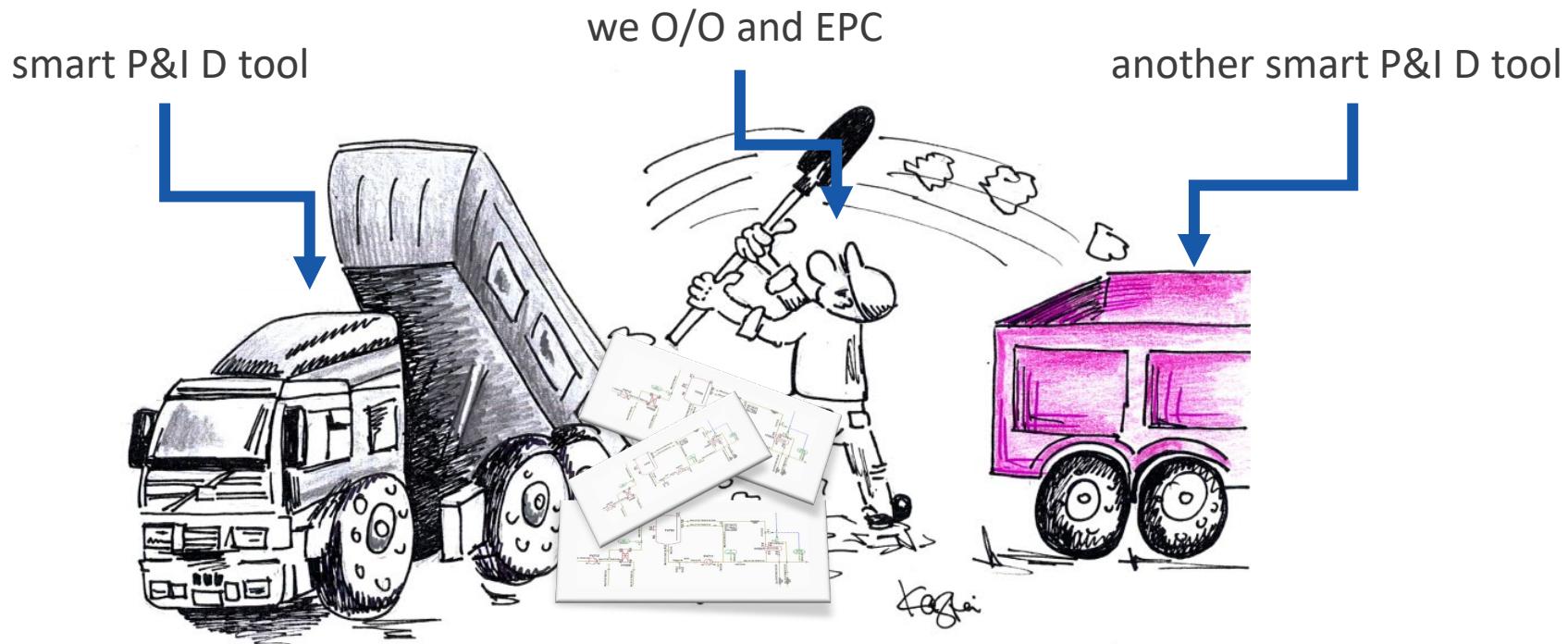
Our focus is the exchange of information for process and plants (data, models and structures). This comprises information contained in flow diagrams (BFDs/PFDs) and piping and instrumentation diagrams (P&IDs).

We work together with other organisations to get aligned specifications for the whole asset life cycle of the process industry.

DEXPI Process and Plant



Problem statement 2012



DEXPI approach



Think global, start with limited scope



Methodology: ISO 15926 + Proteus (XMpLant) scheme

All main CAE software vendors involved

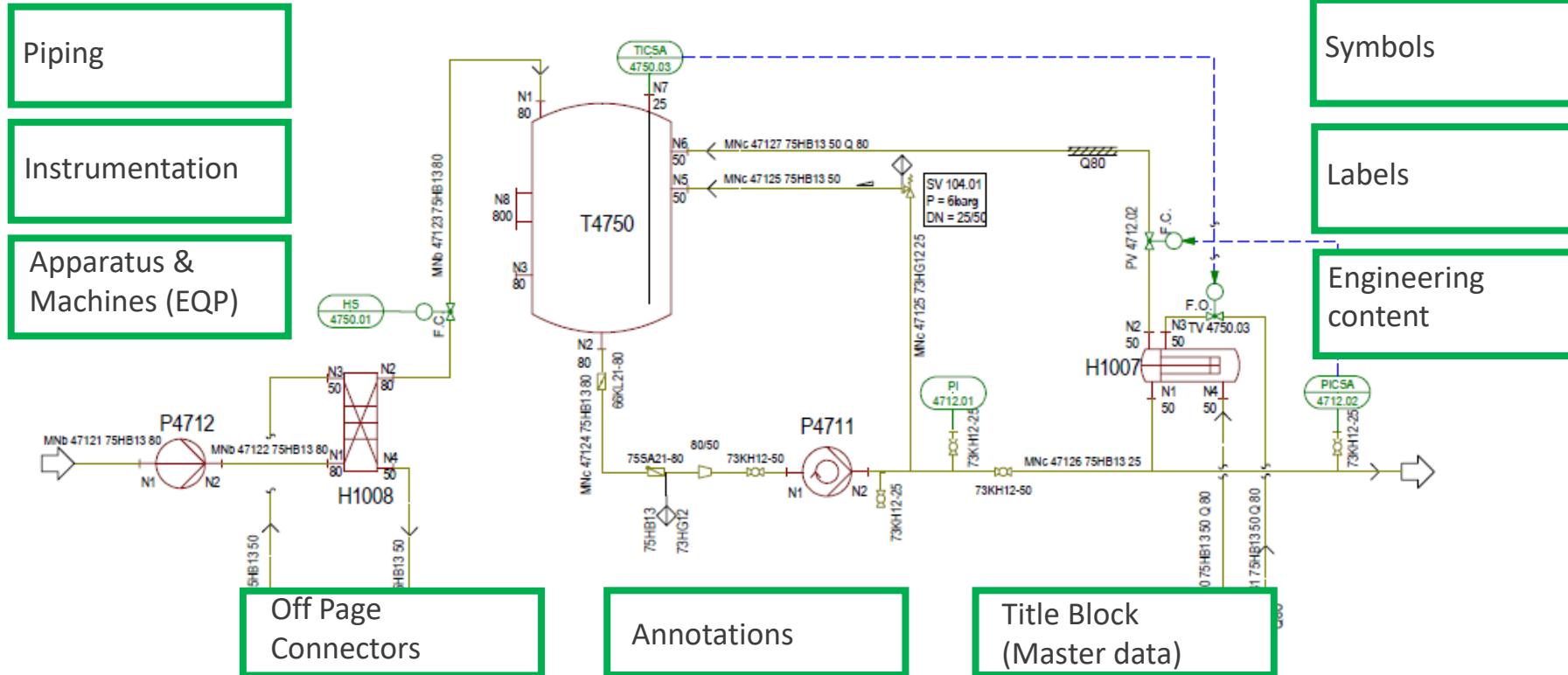
Use existing standards (Do not re-invent the wheel)

Bottom up, pragmatic approach

International coverage, not only local

P&I Ds are central information carrier

A P&I D connects different disciplines in one document'



Design Principles



The DEXPI activities are driven by several basic development guidelines

Openness and transparency of the data model, test cases and communication

Usage of international, accepted standards

Relation to different life cycle aspects

Digitalization = step from Documents to Data

Separation between engineering content and graphics

use of UML concepts like specialization and decomposition for the modelling of engineering and plant objects

International Standards



ISO and IEC

- DEXPI specification based on international standards
- Applicable for IEC, ISA and DIN based P&IDs

Plant Structure	Apparatus / Machines	Piping components	Instrumentation	Communication
ISO 10209	ISO 10628	ISO 10628	IEC 62424	ISO 15926
			IEC 61987	Proteus 4.0.1 (formerly XMpLant)

Plant Breakdown Structure



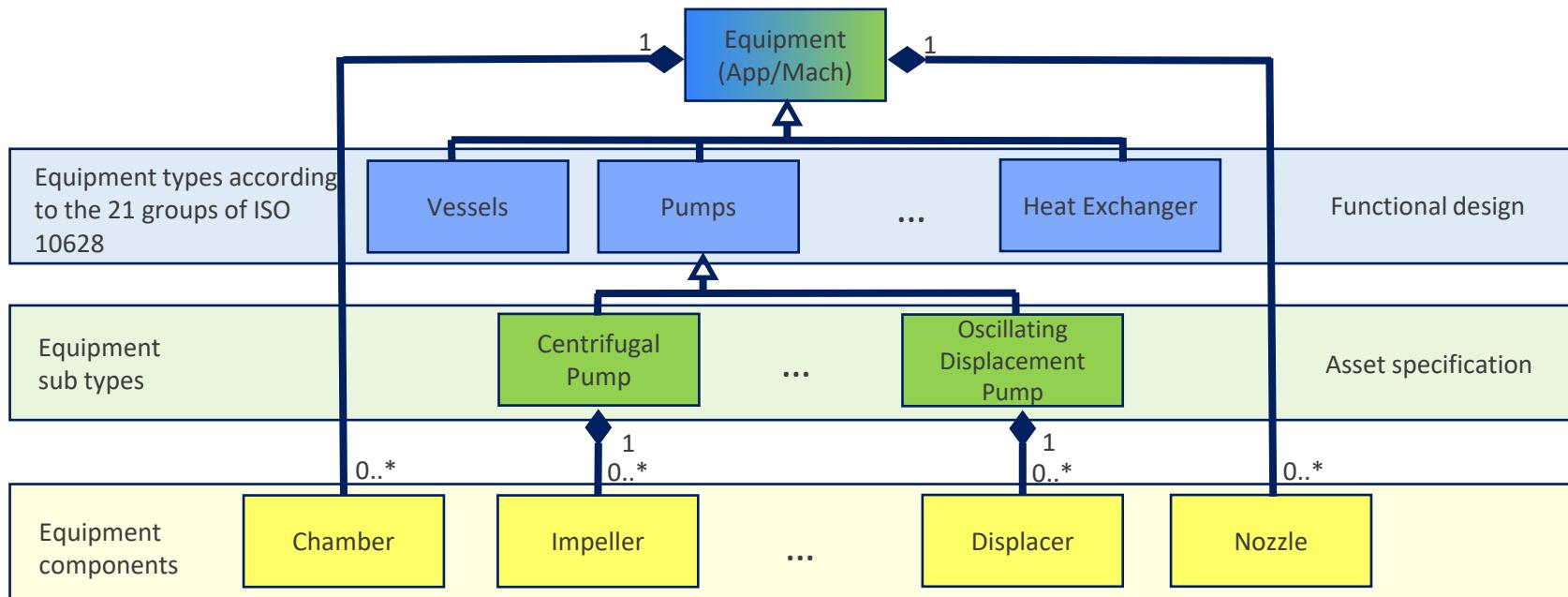
Based on ISO 10209

Elements of the identification system for a process plant

ISO 10209:2012		ISA 95	DIN 28000-3		DEXPI
en	de		en	de	major additional
works	Werk	Enterprise Site Area	Site	Standort	Enterprise Site Area
industrial complex	Anlagenkomplex		Industrial Complex	Anlagenkomplex, Betrieb	Industrial Complex
process plant	verfahrenstechnische Anlage	Process Cell	Process Plant/Plant Unit	Verfahrenstechnische Anlage	Process Plant
plant	Anlage				
plant section	Teilanlage	Unit	Subprocess/Plant Component	Teilanlage	Plant Section
Equipment	Anlagenteil		Technical Item	Technische Einrichtung	Plant Item

Equipment Taxonomy

Based on ISO 10628 and ISO 14224



Specialization of

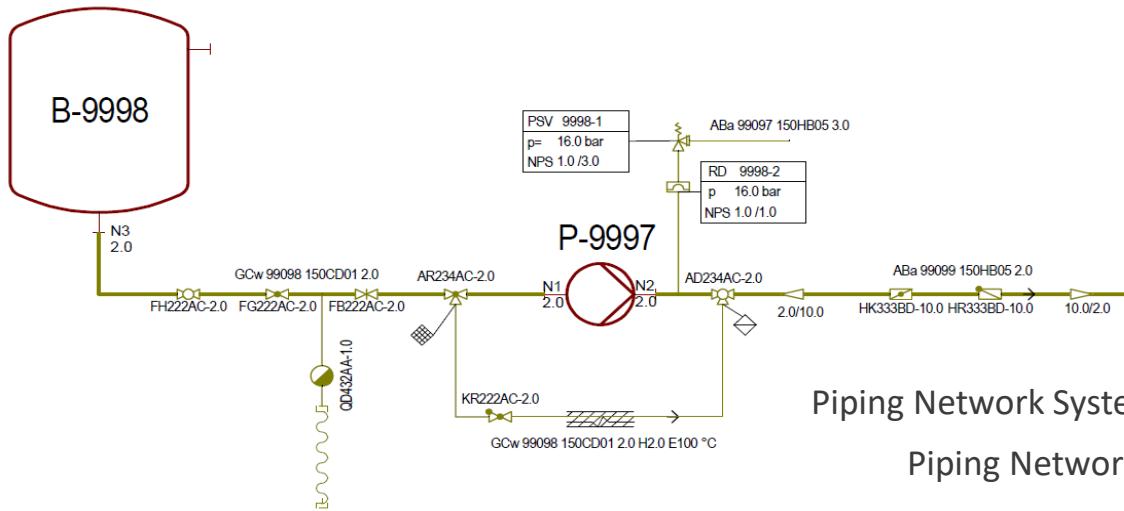


Part of



Piping Taxonomy

Based on ISO 10628



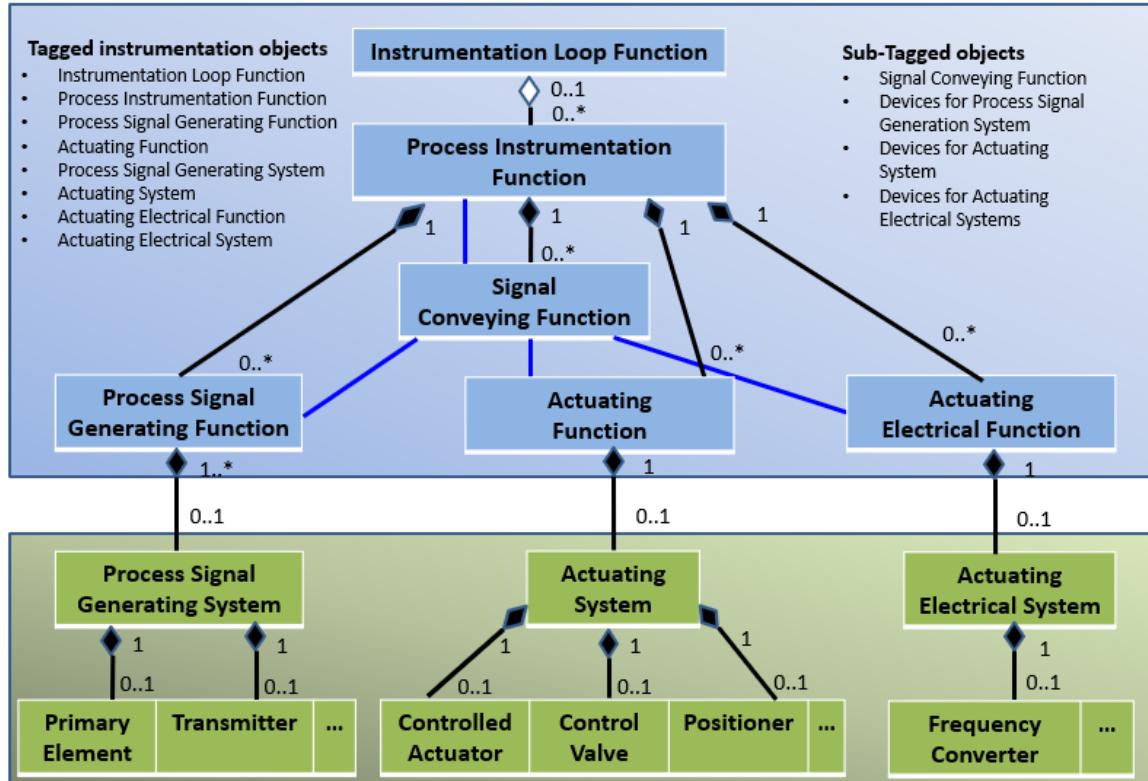
Piping Network System

Piping Network Segment

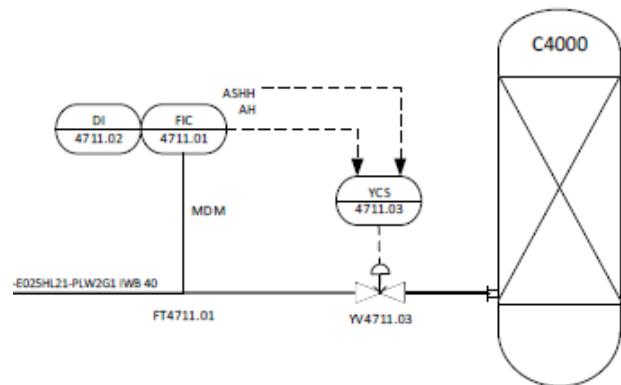
Piping Components (ISO 10628:2012)

21	Valves
22	Check valves
23	Valves and fittings with safety function
24	Fittings

Instrumentation



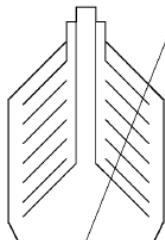
based on:
IEC 62424



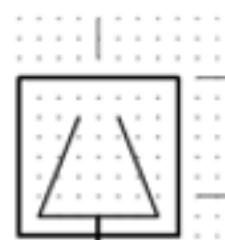
based on:
IEC 61987

Symbols

- DEXPI Plant is a data driven exchange standard
- Symbols can be related to very instance
- Symbols can be identified via IEC 81714-2 and ISO 15519
 - Domain
 - Symbol-No
 - Orientation
 - Version
- by importing a P&I D a symbol change is possible
- Example: Centrifuge



Norsok Z-004
PE030A
A
1998



ISO 10628-2
X2619
A
2012

Deliverables DEXPI Plant



www.dexpi.org

1. DEXPI Specification for Exchange of PIDs (Version 1.3)

first release 1.1 appears in 2016

2. Extension for the Proteus Scheme (resulting in Version 4.0.1)

3. Tools & Test cases

4. CAE Interfaces of the leading PID software

Software & Technology

- Aucotec
- Autodesk
- Aveva
- Cadmatic
- CGC
- Hexagon
- IA
- iTandFactory
- PNB
- PTC
- Semantum
- Siemens
- Yokogawa



DEXPI Plant specification

internally UML (xmi), RDF(s)+JSON - converted to HTML and PDF



dexpi.plants-and-bytes.de/reference/Equipment/Pump.html

Pump

Show Examples
 Show Proteus

DEXPI P&ID Specification 1.3

Overview

Class

A machine that is capable of pumping but may require parts and subsystems for that capability.

For the sake of clarity, superclasses and associations of TechnicalItem are not shown in this diagram.

```

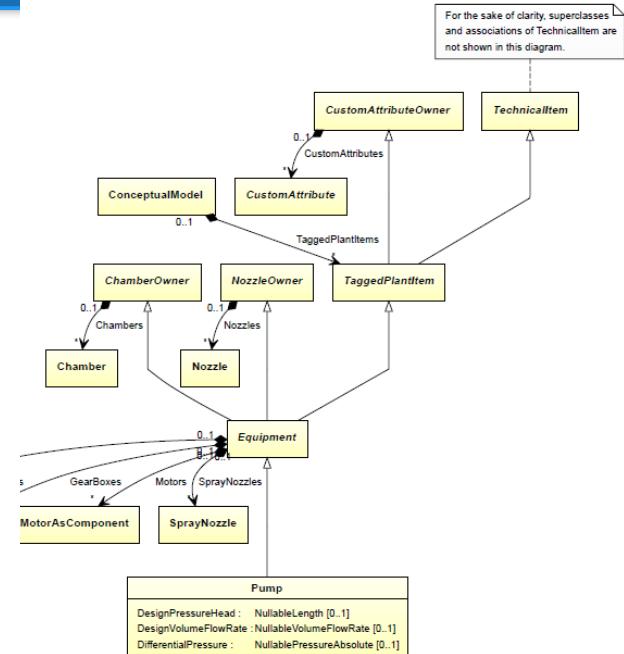
classDiagram
    class ConceptualModel
    class CustomAttributeOwner
    class CustomAttribute
    class TechnicalItem
    class TaggedPlantItem
    class ChamberOwner
    class NozzleOwner
    class Chamber
    class Nozzle
    class Equipment
    class DryingChamber
    class GearBox
    class MotorAsComponent
    class SprayNozzle
    class Pump

    ConceptualModel "0..1" -- "0..1" CustomAttributeOwner : CustomAttributes
    ConceptualModel "0..1" -- "0..1" TaggedPlantItem : TaggedPlantItems
    CustomAttributeOwner "*" -- "0..1" CustomAttribute : CustomAttributes
    CustomAttributeOwner "*" -- "0..1" TaggedPlantItem : TaggedPlantItems
    CustomAttribute "*" -- "0..1" TaggedPlantItem : TaggedPlantItems
    ChamberOwner "*" -- "0..1" Chamber : Chambers
    NozzleOwner "*" -- "0..1" Nozzle : Nozzles
    Chamber "0..1" -- "0..1" Equipment : Chambers
    Nozzle "0..1" -- "0..1" Equipment : Nozzles
    Equipment "*" -- "0..1" DryingChamber : DryingChambers
    Equipment "*" -- "0..1" GearBox : GearBoxes
    Equipment "*" -- "0..1" MotorAsComponent : Motors
    Equipment "*" -- "0..1" SprayNozzle : SprayNozzles
    DryingChamber --> Pump
    GearBox --> Pump
    MotorAsComponent --> Pump
    SprayNozzle --> Pump

    class DesignPressureHead : NullableLength [0..1]
    class DesignVolumeFlowRate : NullableVolumeFlowRate [0..1]
    class DifferentialPressure : NullablePressureAbsolute [0..1]

    Pump {
        DesignPressureHead : NullableLength [0..1]
        DesignVolumeFlowRate : NullableVolumeFlowRate [0..1]
        DifferentialPressure : NullablePressureAbsolute [0..1]
    }
  
```

DEXPI P&ID Specification 1.3



DEXPI Plant Tools



DEXPI Viewer and Verifier

The tool is a viewer for P&IDs that allows access to all data and graphical details of an imported DEXPI-compliant Proteus XML file. A detailed verification report lists all issues detected during the import.

- Download [PID Verifier 1.0.1](#).



DEXPI Sandbox RDL

ISO 15926 part 4 is the primary RDL for DEXPI

The DEXPI Sandbox RDL is an ISO 15926 compliant Reference Data Library (RDL). It provides definitions for classes used by the DEXPI P&ID Specification.

- Explore the [web version of the RDL](#).
- Access the underlying [SPARQL endpoint](#) (select the RDL dataset).



Code, data and specification repository

We use a Gitlab repository for code versioning, issue tracking and tool collection. More info: <https://gitlab.com/dexpi>



SVG Graphic Builder

The SVG Graphic Builder converts a [ProteusXML](#) file into an [SVG](#) file. SVG files can be visualized by every modern browser.

- [GraphicBuilder Project on Gitlab](#)

DEXPI additional workflows

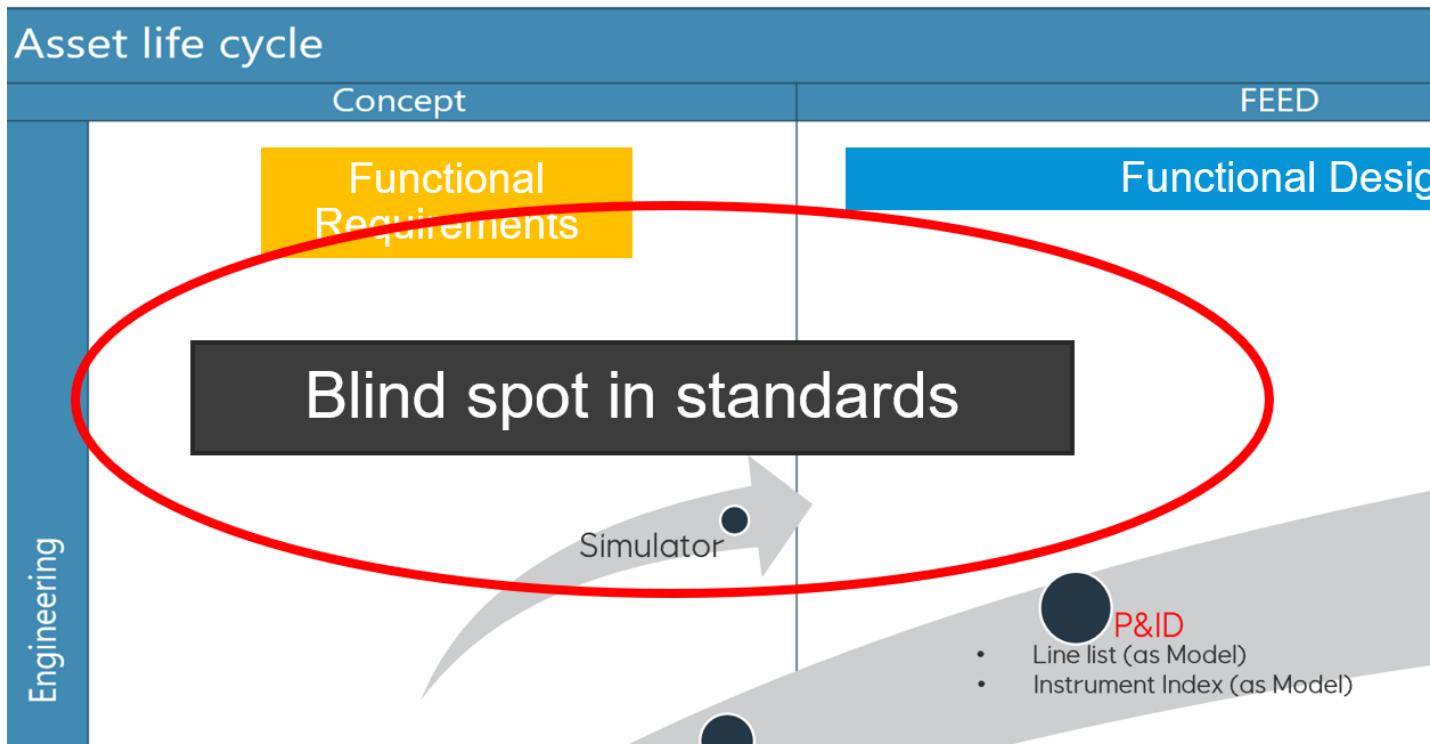


These (data exchange) workflows are supported through the DEXPI standard

Re-use PID information for other disciplines

Instrumentation systems	Process simulation	AR/VR	IoT and control systems	3D piping systems	Mobile solutions	Safety and work permit systems	ERP, Data Management (Plant topology)

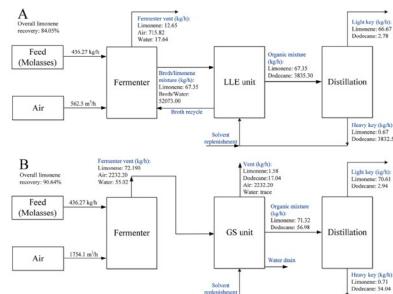
The DEXPI Process addressed a blind spot in the standards landscape



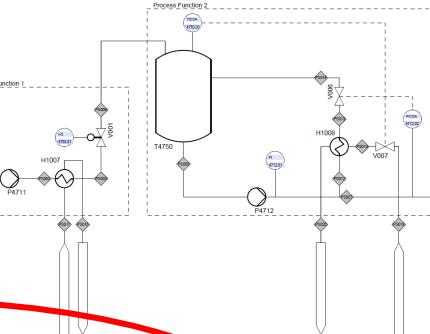
The goal of DEXPI Process is to be an information model for BFDs/PFDs

- In 2022, the project was started (see e.g. THTH autumn webinar November 2022).

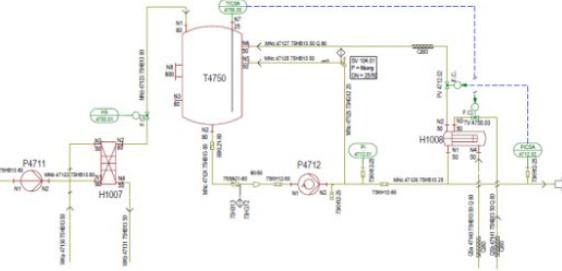
BFD Block Flow Diagram



PFD Process Flow Diagram



P&ID Piping & Instrumentation Diagram

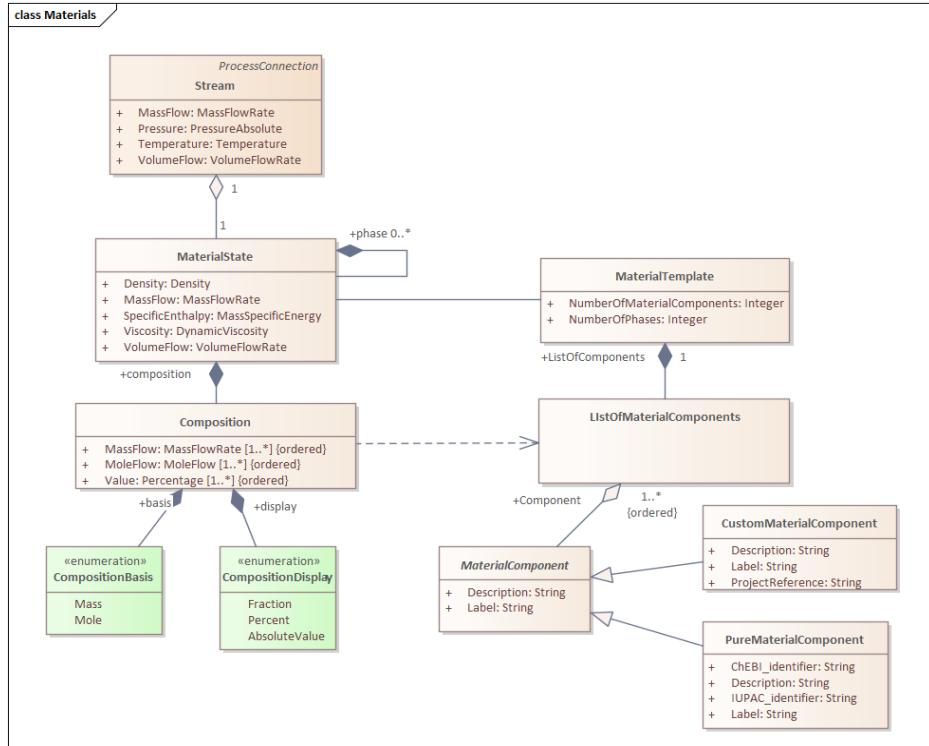


Process Model

Plant Model

Streams provide support for a flexible stream table

Philosophy built on CAPE-OPEN and OntoCAPE



A **Material Template** defines the structure of a family of streams.

The **Material State** object can be configured to contain data for total streams and each phase.

This offers potential for data exchange with simulators. With a CAPE-OPEN specification

A hierarchy of process steps

Characterized by reference data for *activities*, verbs, not things, nouns.

- Generate Flow: Compressing and Pumping.
- Mix.
- Split.
- Transport Material and Energy.
- Store.
- Supply Materials and Energy.
- Supply Exchange of Thermal Energy.
 - Heating, Cooling, Exchange of Heat.
- Separation.
 - Phase separation, Thermal processes, Filtering, Electromagnetics, Physical Processes.
- Process solids.
 - Reduce size, Increase size, Form material.
- React Chemicals.
- Packaging.



The outcome, DEXPI Process, was published in 2023



<https://dexpi.org/wp-content/uploads/2023/12/DEXPI-Process-1.0-Manual.pdf>

DEXPI Process Modelling of Process Systems and their Documentation

Authors: David Cameron, Wilhelm Otten, Heiner Temmen, Gregor Tolksdorf

DEXPI+ Project Team: David Cameron (University of Oslo), Andreas Schüller (NAMUR), Anselm Klose (TU Dresden), Behnam Ghahraman (Aucotec), Eric Carnet (Aveva), Iskandar Halim (ISCEE), Leon Hanke (Aucotec), Maged Selim (Aveva), Manfred Theißen (PNB), Martin te Lintelo (USPI), Monica Hole (Aibel), Idar Pe Ingebrigtsen (Equinor)

<https://dexpi.org/dexpi-process-specification-1-0-released/>

DEXPI Process Specification 1.0 released

2023-12-15

https://dexpi.org/static/process_model_1.0/index.html



DEXPI Process

Version 1.0

Released by the DEXPI Initiative on December 15, 2023

2024-09-13

<https://www.sciencedirect.com/science/article/pii/S0098135423004349>



Computers & Chemical Engineering
Volume 182, March 2024, 108564



DEXPI process: Standardizing interoperable information for process design and analysis

David B. Cameron^a , Wilhelm Otten^b, Heiner Temmen^c, Monica Hole^d, Gregor Tolksdorf^e

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<https://doi.org/10.1016/j.compchemeng.2023.108564> 

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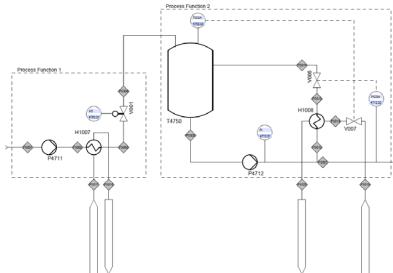
 open access

DEXPI 2.0 will combine Process and Plant into one information model



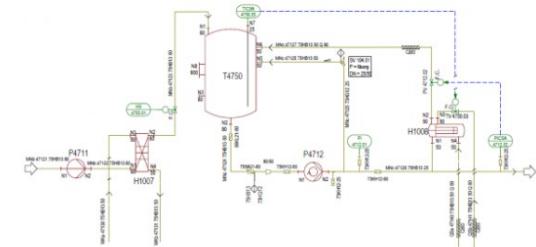
DEXPI

Process
BFD/PFD



DEXPI

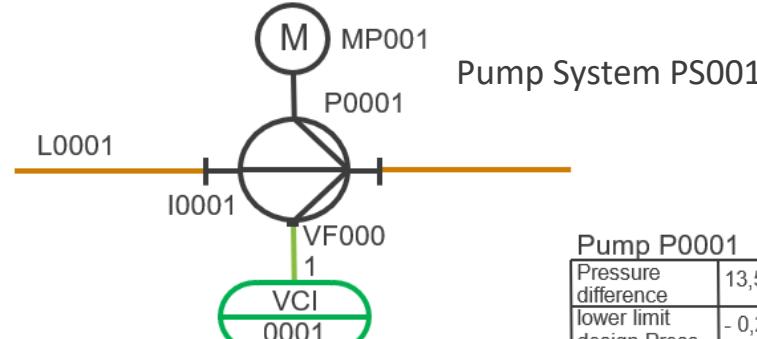
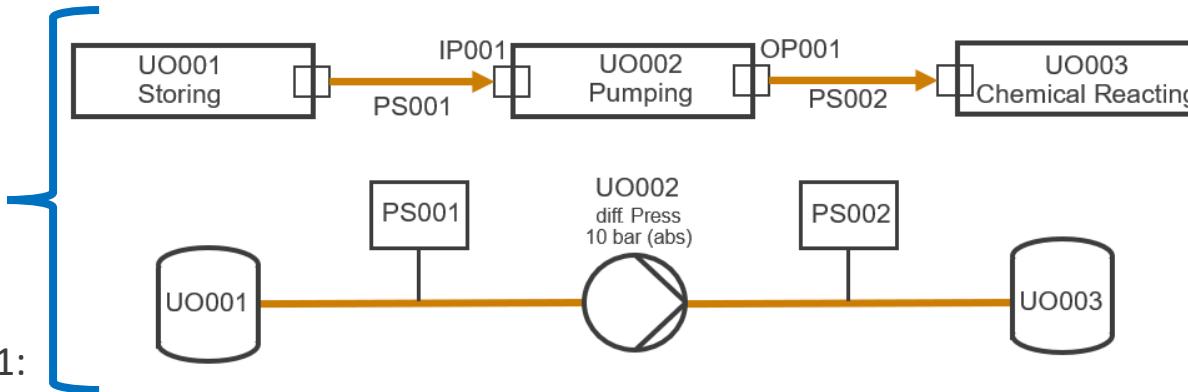
Plant
P&I D



DEXPI 2.0

Process &
Plant

IDO use case 7: Pump life cycle story - from process to process plant to assets



Pump P0001	
Pressure difference	13,5 bar abs
lower limit design Press	- 0,2 bargauge
upper limit design Press	30 bargauge

Ongoing work in week 39: IDO and DEXPI



- Continuation of the work to solve use case 7 with IDO concepts
- The IDO ontology 'process' contains some DEXPI process classes, but not all. It should be populated with all.
- The IDO ontology 'equipment' contains some DEXPI plant classes, but not all. It should be populated with all.
- Extent to scope from DEXPI to CFIHOS

CFIHOS overview

Our Purpose

The purpose of CFIHOS is to create a handover specification that can be implemented by operators, contractors and equipment manufacturers and suppliers to standardize the specification of information handover requirements for a project.

That is required to own, operate, maintain a facility safely, efficiently and demonstrate compliance to the regulator.

Which is significantly lowering the lifecycle cost associated with incorrect and missing information required to operate a facility.

Our Membership

CFIHOS currently has 83 organisations participating, with over 400 SMEs contributing to the development of the specification across multiple industry sectors.

IOGP Owner Operators	14
Non IOGP Members Owner Operators	10
Software Vendors & Consultants	30
EPC Contractors	23
Equipment Suppliers and Others	6

With 400+ SMEs from the member organizations

Our MOU Partners

Alignment of key industry initiatives to strengthen our common data language



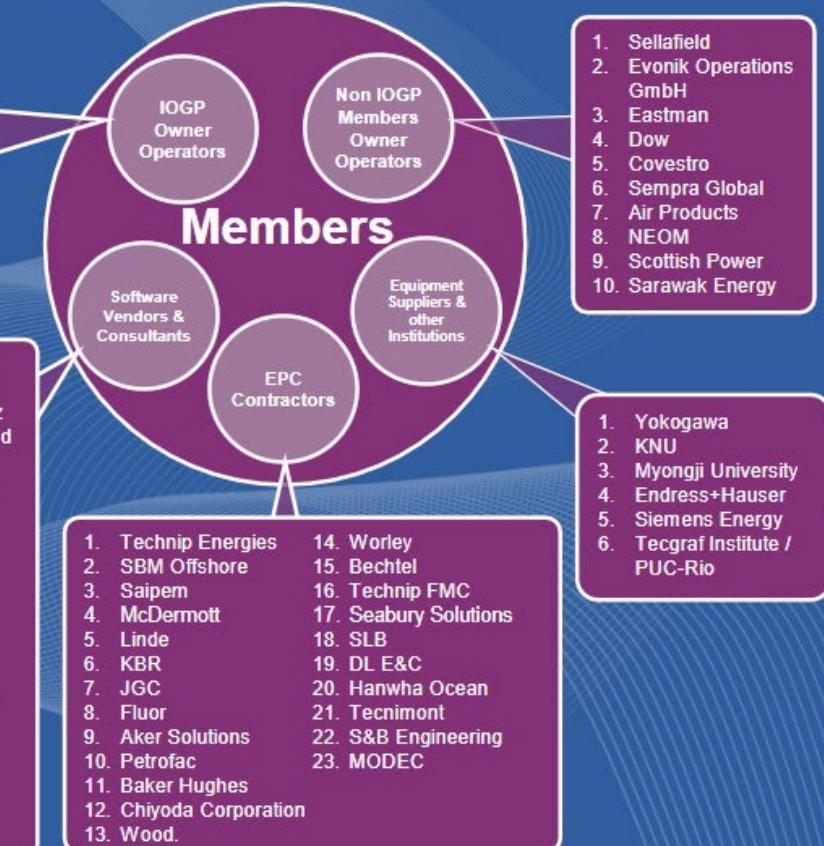
An IOGP programme



CFIROS membership 2024-06

- 1. Woodside
- 11. Chevron
- 2. TotalEnergies
- 12. BP
- 3. Suncor Energy Inc
- 13. Saudi Aramco
- 4. Shell
- 14. AkerBP
- 5. Petronas
- 6. Petrobras
- 7. ExxonMobil
- 8. Equinor
- 9. ENI
- 10. ConocoPhillips

- 1. Aucotec
- 19. L&T Technology Services (LTTS)
- 2. Sharecat
- 20. Austin Fernandez Consulting Limited
- 3. Plant Resource Technology
- 21. RZON™ TECHNOLOGY
- 4. Kraken
- 22. AspenTech
- 5. Hexagon
- 23. AiFlux Limited
- 6. Aveva
- 24. Semmtech
- 7. Accenture
- 25. GDIS
- 8. Talent Swarm
- 26. Stratopa
- 9. Idox
- 27. Incitus
- 10. ReVision Inc.
- 28. Rihal
- 11. DMS Corporation
- 29. PlantStream3D
- 12. Dassault Systèmes
- 30. Bentley Systems
- 13. Autodesk
- 14. Assai
- 15. Wipro
- 16. Phusion IM
- 17. Datum 360
- 18. Covestro



Participation in CFIROS has grown to 83 organizations across multiple industry sectors, with 400+ SMEs from the member organizations.

IOGP Owner Operators	14
Non IOGP Members Owner Operators	10
Software Vendors & Consultants	30
EPC Contractors	23
Equipment Suppliers and Others	6
Total Organisations	83

Key elements of CFIHOS

Narrative Documents library

Scope and procedures Document

How to define the scope of Information Management to support delivery of CFIHOS requirements

Technical Specification Document

Requirements, rules and principles for information handover

Process & Guidance Documents

Outlining implementation steps (and do's & don'ts)



Data Model

For structuring data and documents about assets

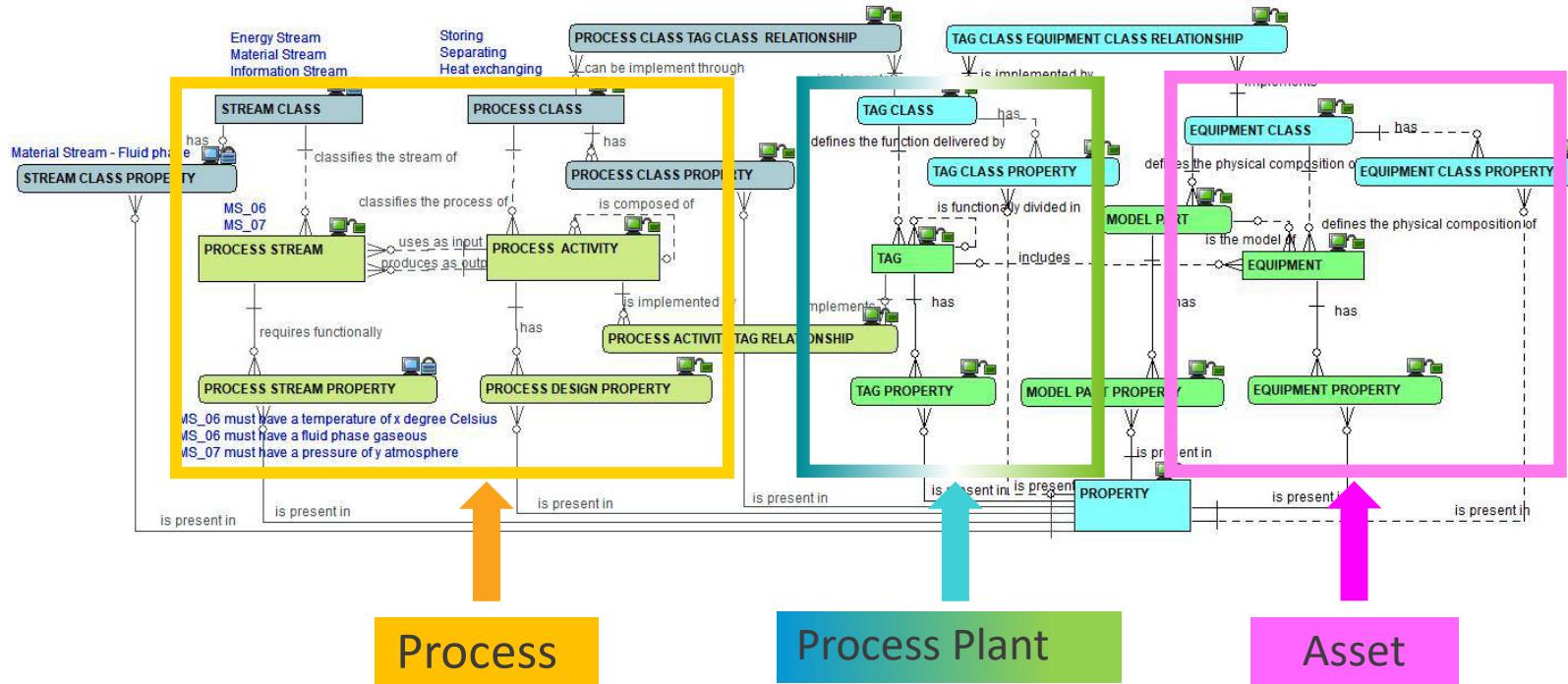


Reference Data Library (Dictionary)

Consistent naming of equipment, properties & documents



Life cycle in CFIHOS data model



CFIHOS / DEXPI alignment

- based on CFIHOS V2 with 853 tag classes
- commitment of P&I D relevance
 - about 170 apparatus & machine classes
 - about 95 piping classes
 - about 200 instrumentation classes
 - about 125 classes of other disciplines like infrastructure, health & safety and environment equipment classes
- Integration into DEXPI plant taxonomy
 - first cut is done for apparatus & machine, piping and instrumentation
 - work in progress
 - time line: end of 2024
 - with SKOS mapping
 - integration of other disciplines has to be discussed

CFIHOS / DEXPI alignment: examples

DEXPI root class	ISO 10628-2:2012 group	DEXPI apparatus / machine type	DEXPI sub type (specialization)	DEXPI component (part of)	CFIHOS tag class name	CFIHOS unique id	CFIHOS parent tag class name	RDL2 class
15	Pump				pump	CFIHOS-30000550	mechanical equipment class	PUMP
		CentrifugalPump			centrifugal pump	CFIHOS-30000521	pump	CENTRIFUGAL PUMP
			:Impeller (0..*)					IMPELLER
		ReciprocatingPump			reciprocating pump	CFIHOS-30000862	pump	RECIPROCATING PUMP
			:Displacer (0..*)					DISPLACER
		RotaryPump			rotary pump	CFIHOS-30000864	pump	ROTARY PUMP
			:Displacer (0..*)					DISPLACER
		EjectorPump						EJECTOR PUMP
					eductor	CFIHOS-30000038	pump	EDUCTOR
					vacuum pump	CFIHOS-30001032	pump	VACUUM PUMP
		CustomPump						
			:Impeller (0..*)					IMPELLER
			:Displacer (0..*)					DISPLACER

20	Motor			motor	CFIHOS-30000684	driver	MOTOR
		AlternatingCurrentMotor		alternating current motor	CFIHOS-30000805	electric motor	ALTERNATING CURRENT MOTOR
		DirectCurrentMotor		direct current motor	CFIHOS-30000820	electric motor	DIRECT CURRENT MOTOR
		CombustionEngine					COMBUSTION ENGINE
				driver	CFIHOS-30000683	engine	DRIVER(function)
				pumpjack	CFIHOS-30001011	driver	PUMPJACK
				beam pumpjack	CFIHOS-30001026	pumpjack	???
				long-stroke pumpjack	CFIHOS-30001020	pumpjack	???
				diesel engine	CFIHOS-30000527	engine	DIESEL ENGINE
				gas engine	CFIHOS-30000533	engine	GAS ENGINE
				petrol engine	CFIHOS-30000544	engine	PETROL ENGINE
		CustomMotor					

Interoperability Eco System

