



Data Exchange in the Process Industry - The DEXPI initiative -

M. Wiedau, RWTH Aachen University

PCA SIG Meeting / Semantic Days
May 27th 2013, Stavanger, Norway





Agenda

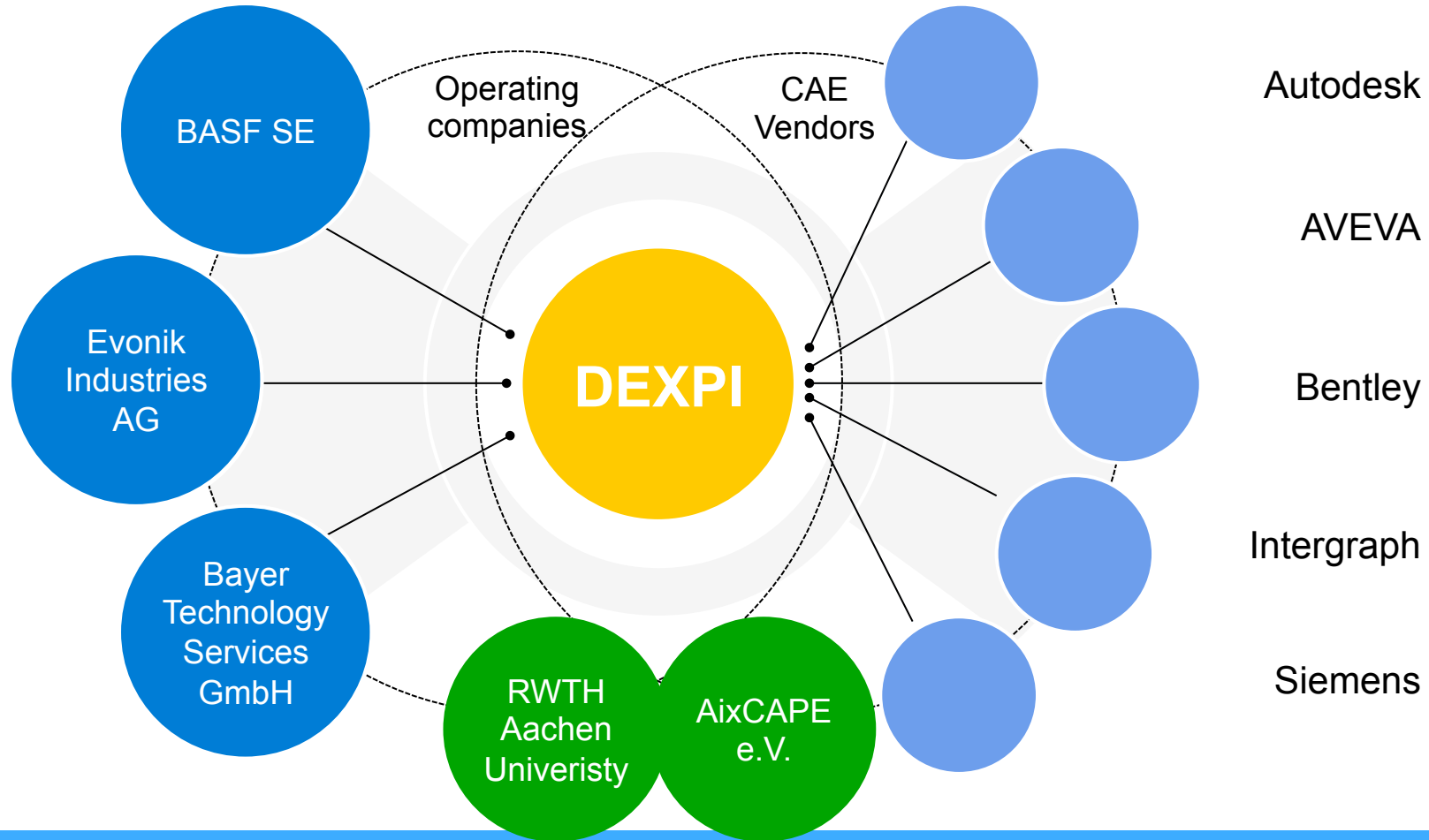
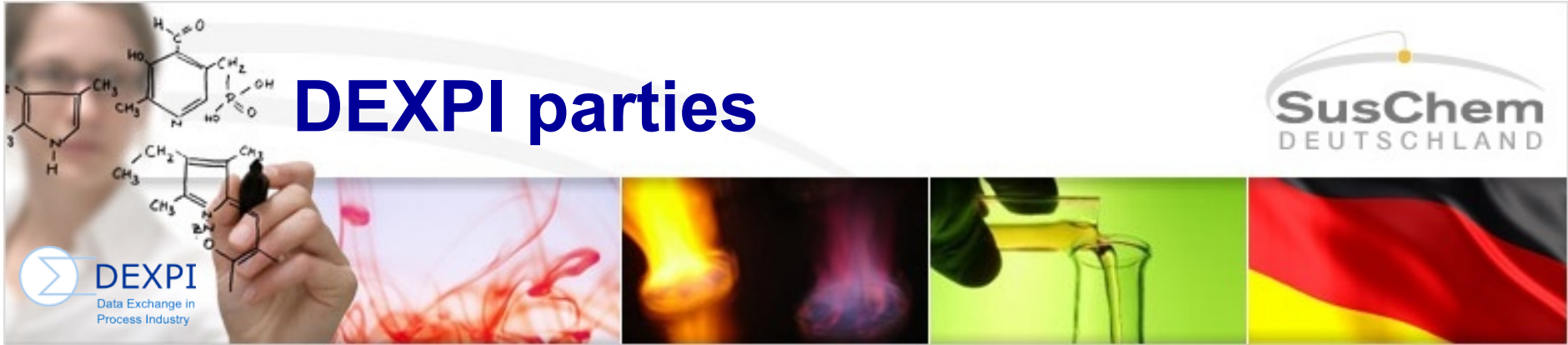
- Why DEXPI and what is it?
- Information Modeling
- Usage of ISO 15926-4 and JORD
- Modeling issues
- Application of the information models
- Model validation
- Summary & Outlook

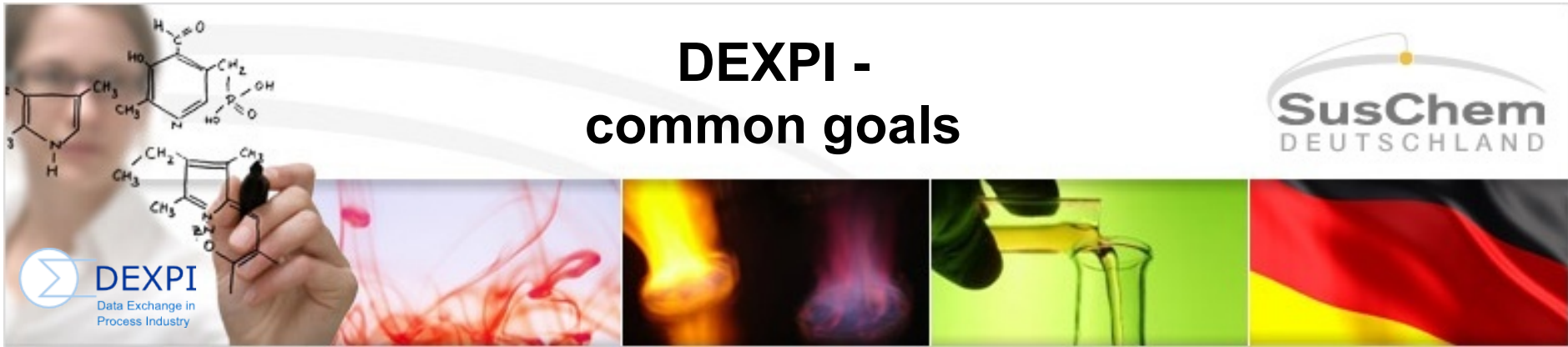
DEXPI – common problem



Lack of interoperability between CAE systems is a major business barrier

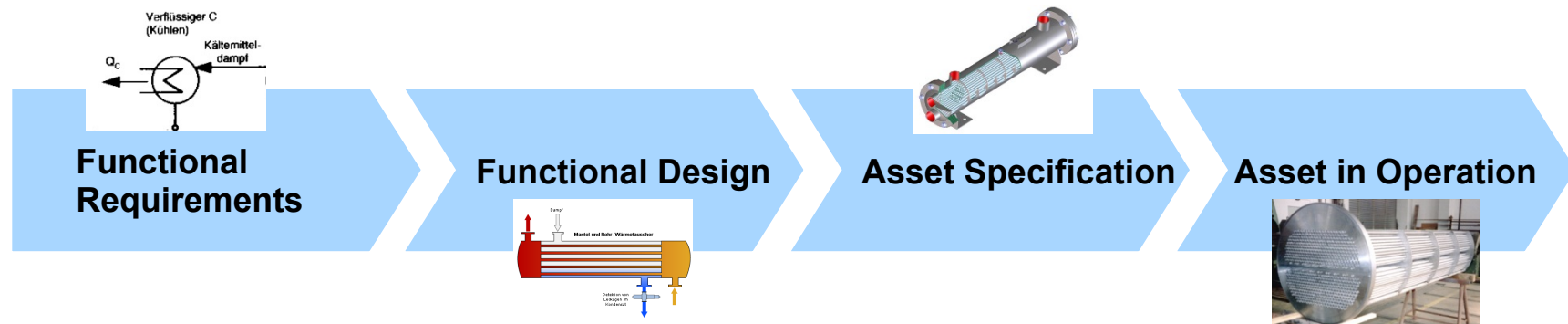






General standard for the process industry based on ISO 15926, implemented in the next CAE software generation

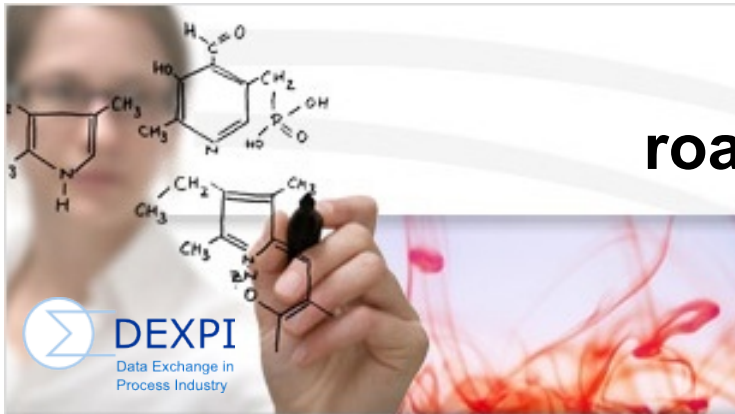
Input from process industry (working party DEXPI ISO 15926):
Open and international information model for the entire plant lifecycle



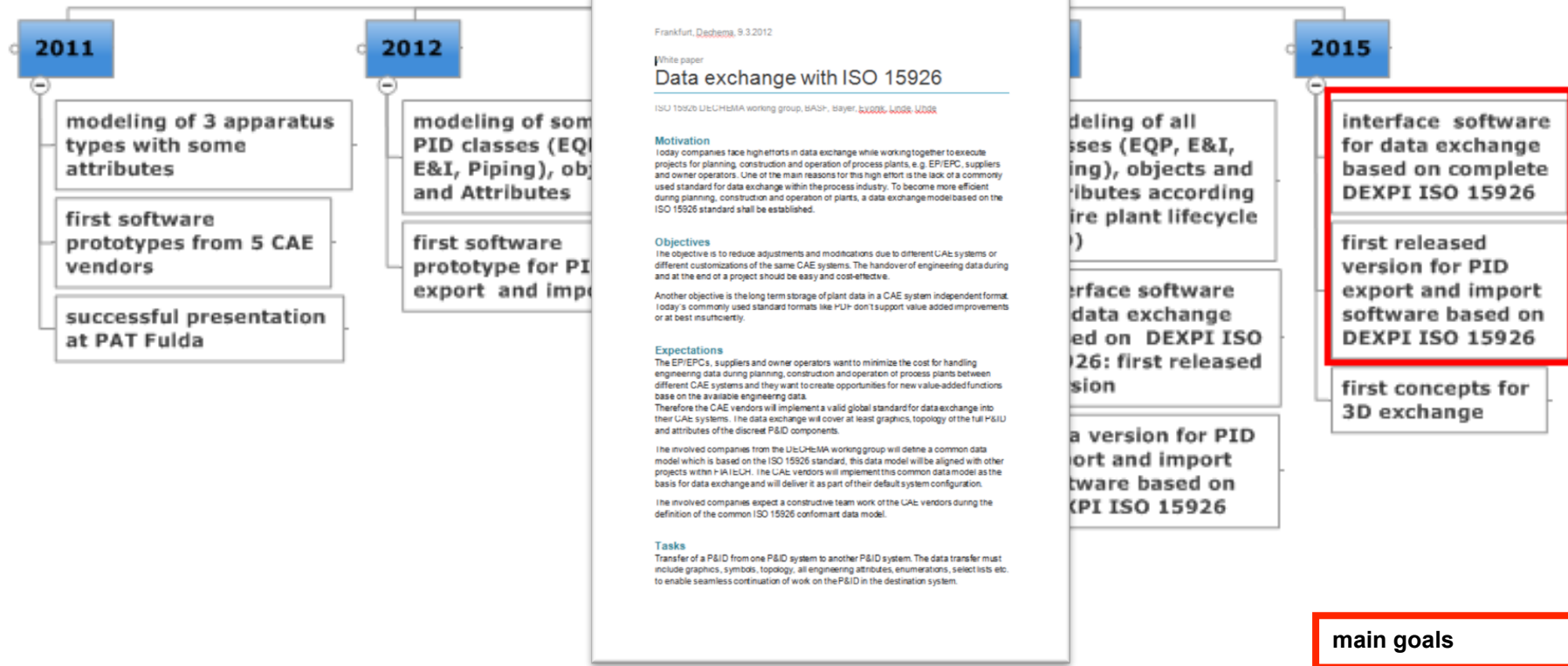
Input from the CAE vendors:

- General exchange standard for graphics
- export and import functions based on the new information model and graphics standard

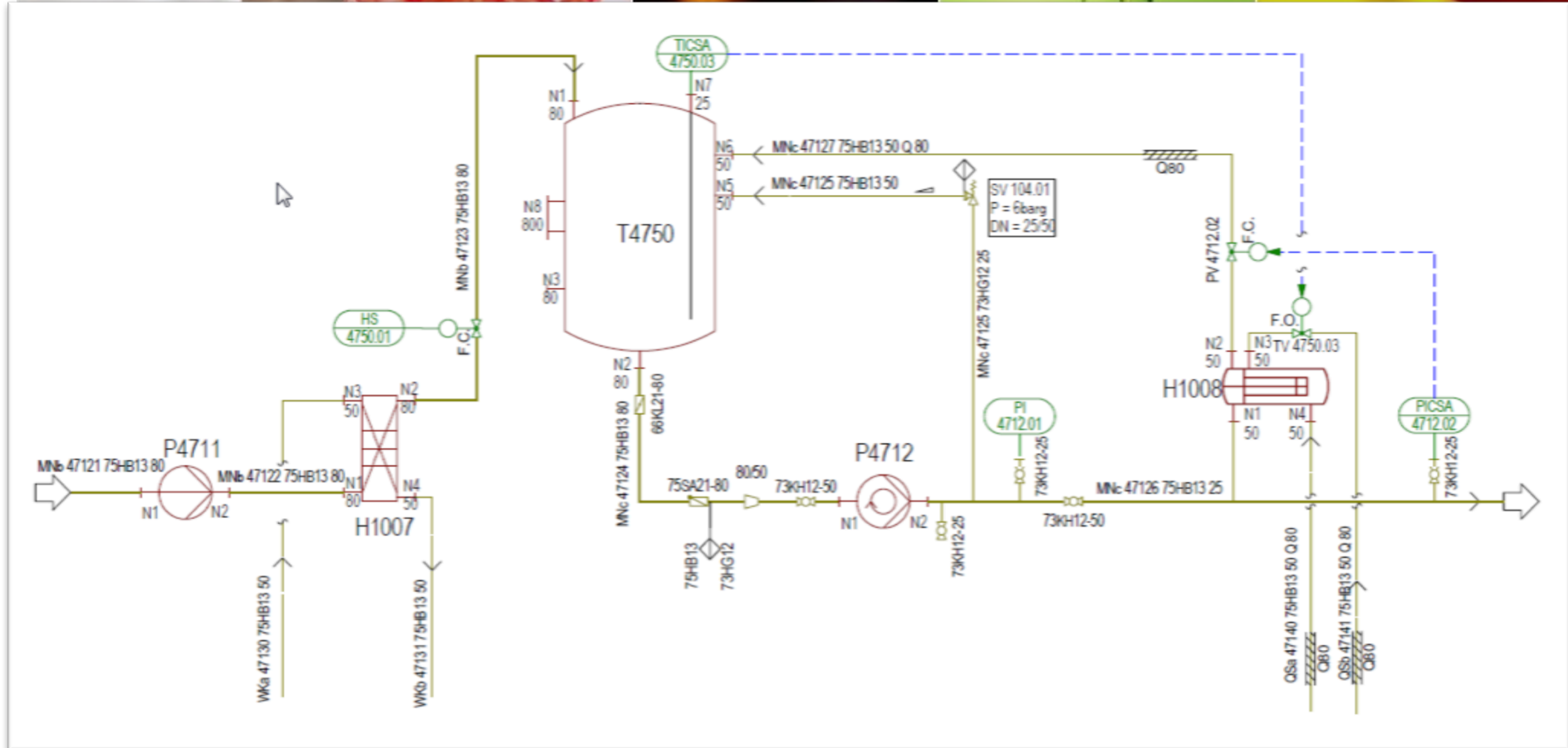
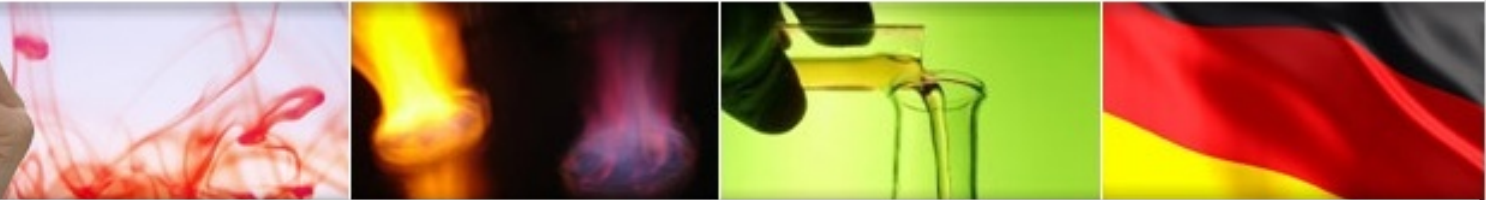
DEXPI - roadmap until 2015



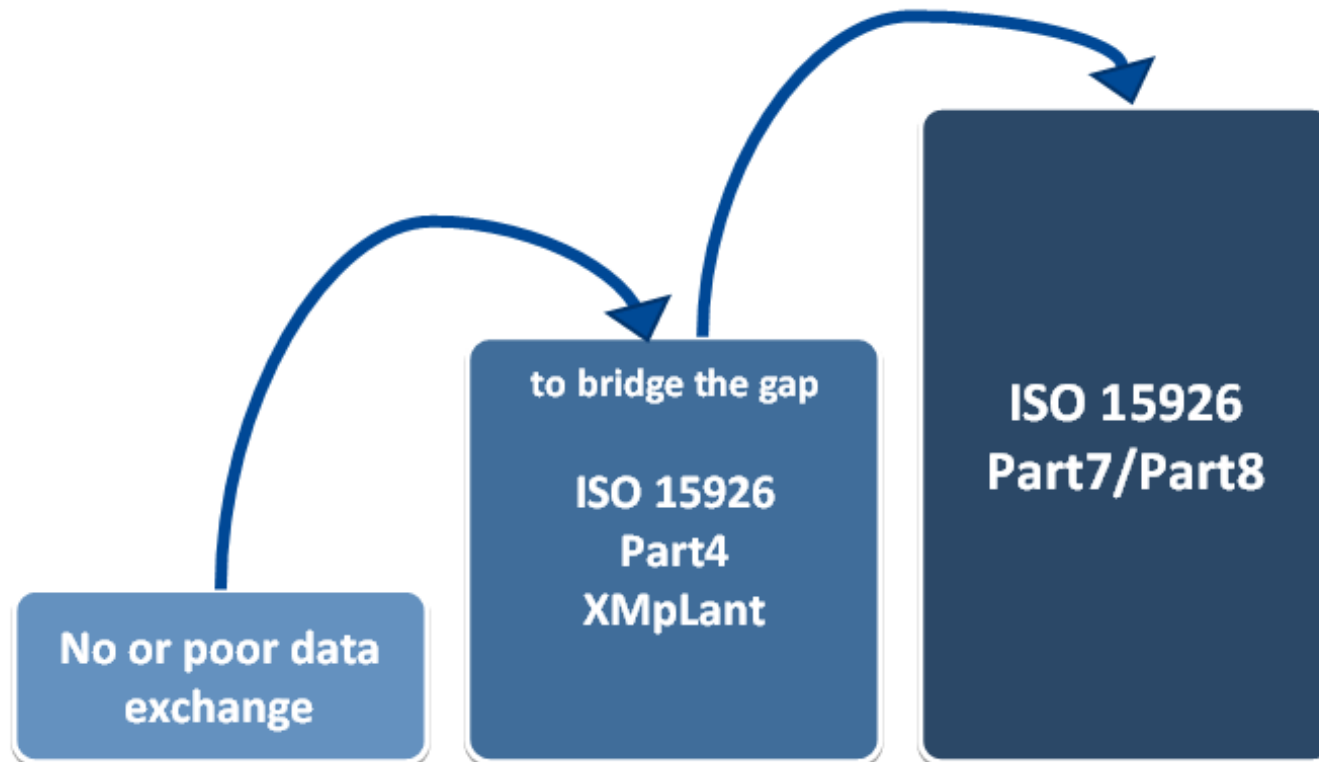
Project Timeline: DEXPI ISO 15926



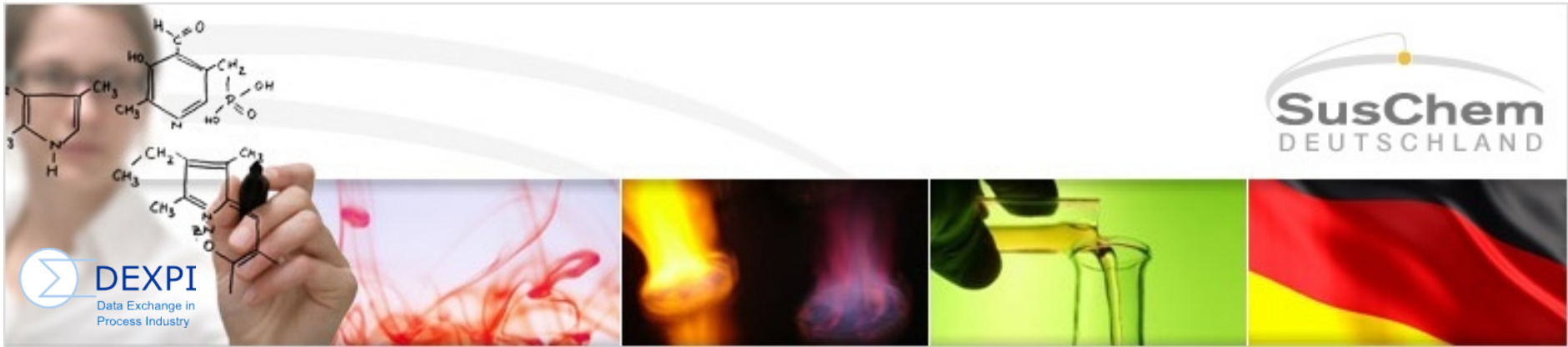
Scope for data exchange - P&ID fragment



Technology – Proteus / XMpLant schema to bridge the gap for P&IDs

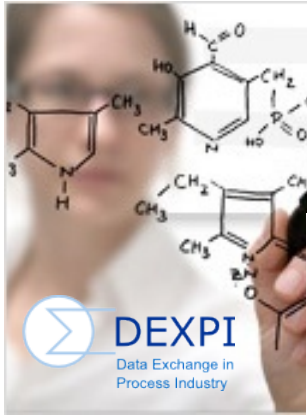


Data part OK, but graphic part is only well under way

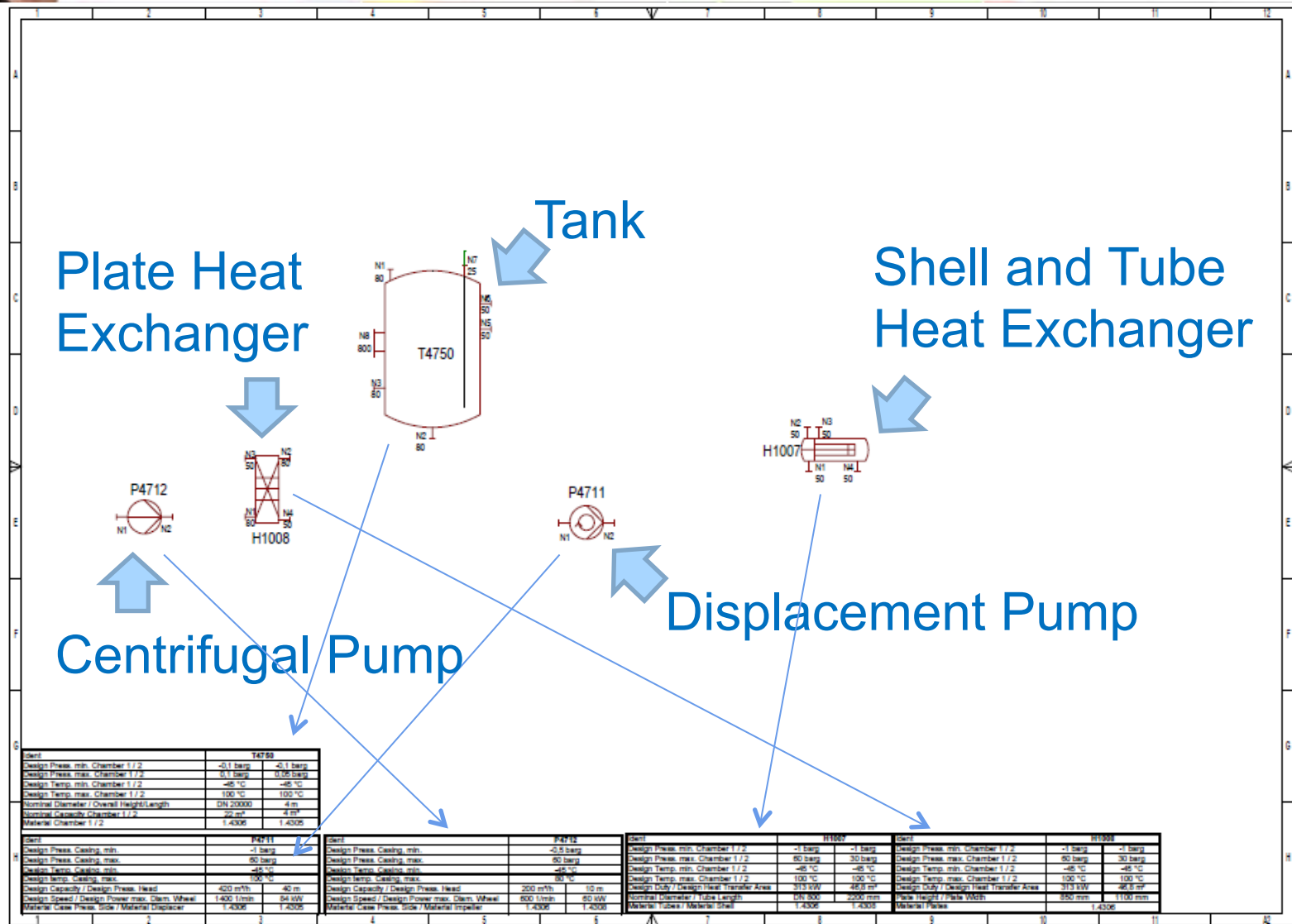


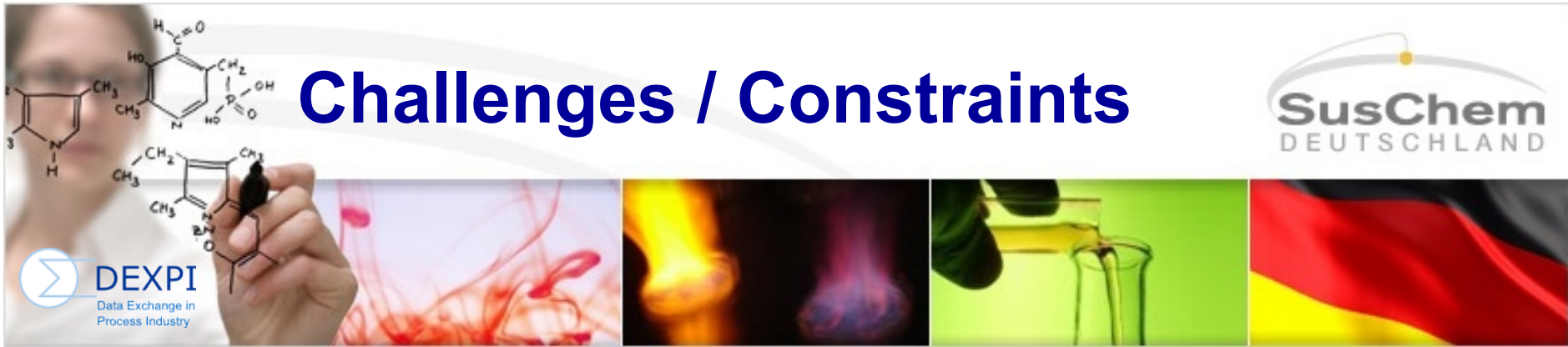
From data to semantics

INFORMATION MODELS FOR ENGINEERING DATA



A first, reduced P&ID ...

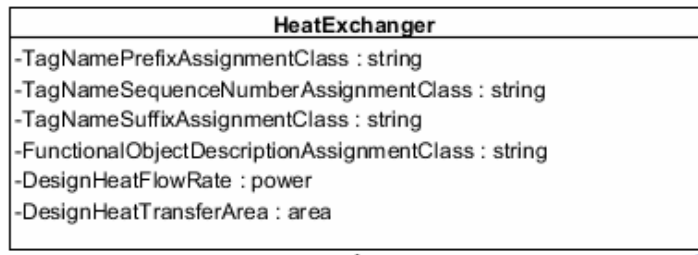
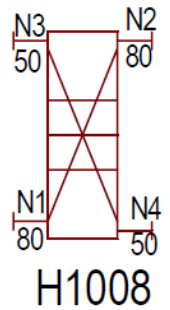
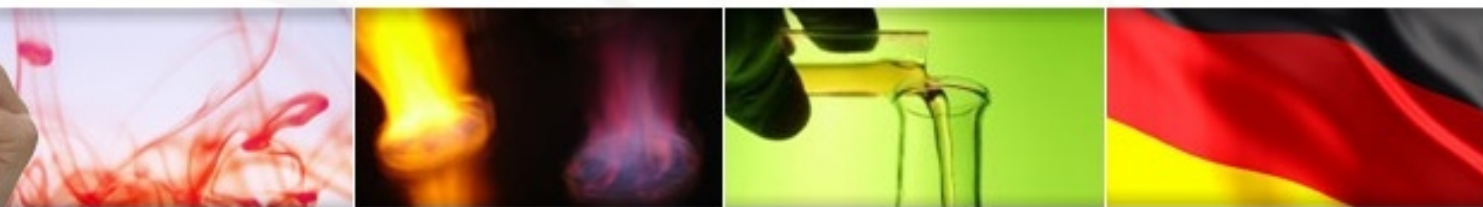




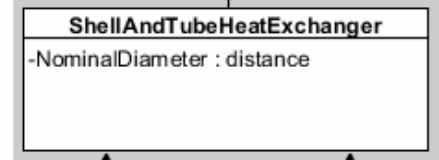
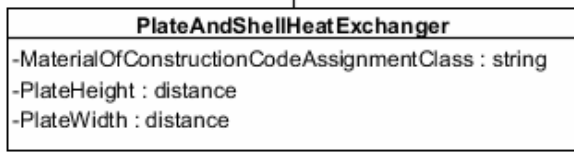
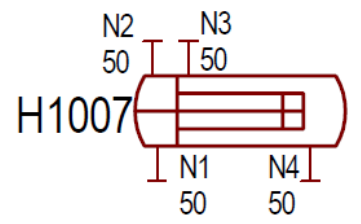
- Use ISO 15926 part 4 vocabulary
- Information models should be generic
- Use XMpLant for bridging the gap
- Verify the software outputs



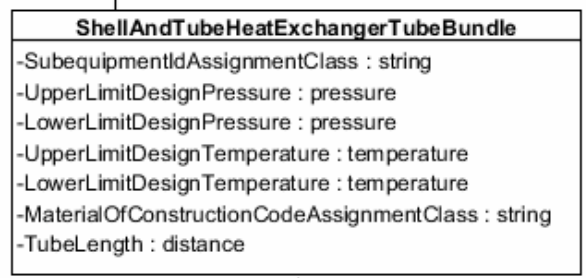
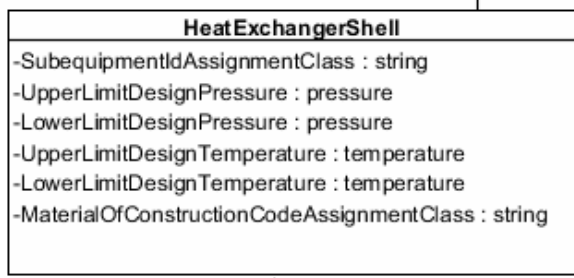
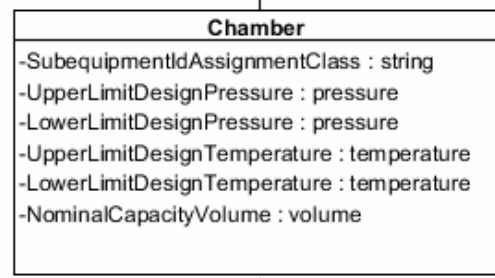
Heat Exchanger

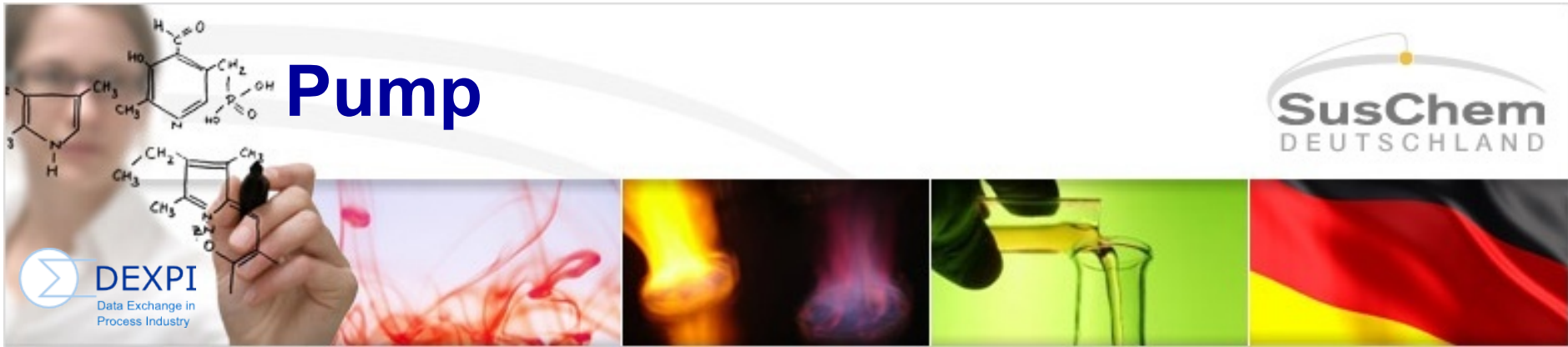


Specialization

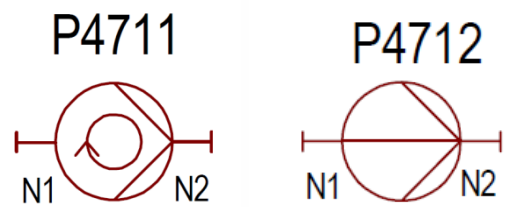
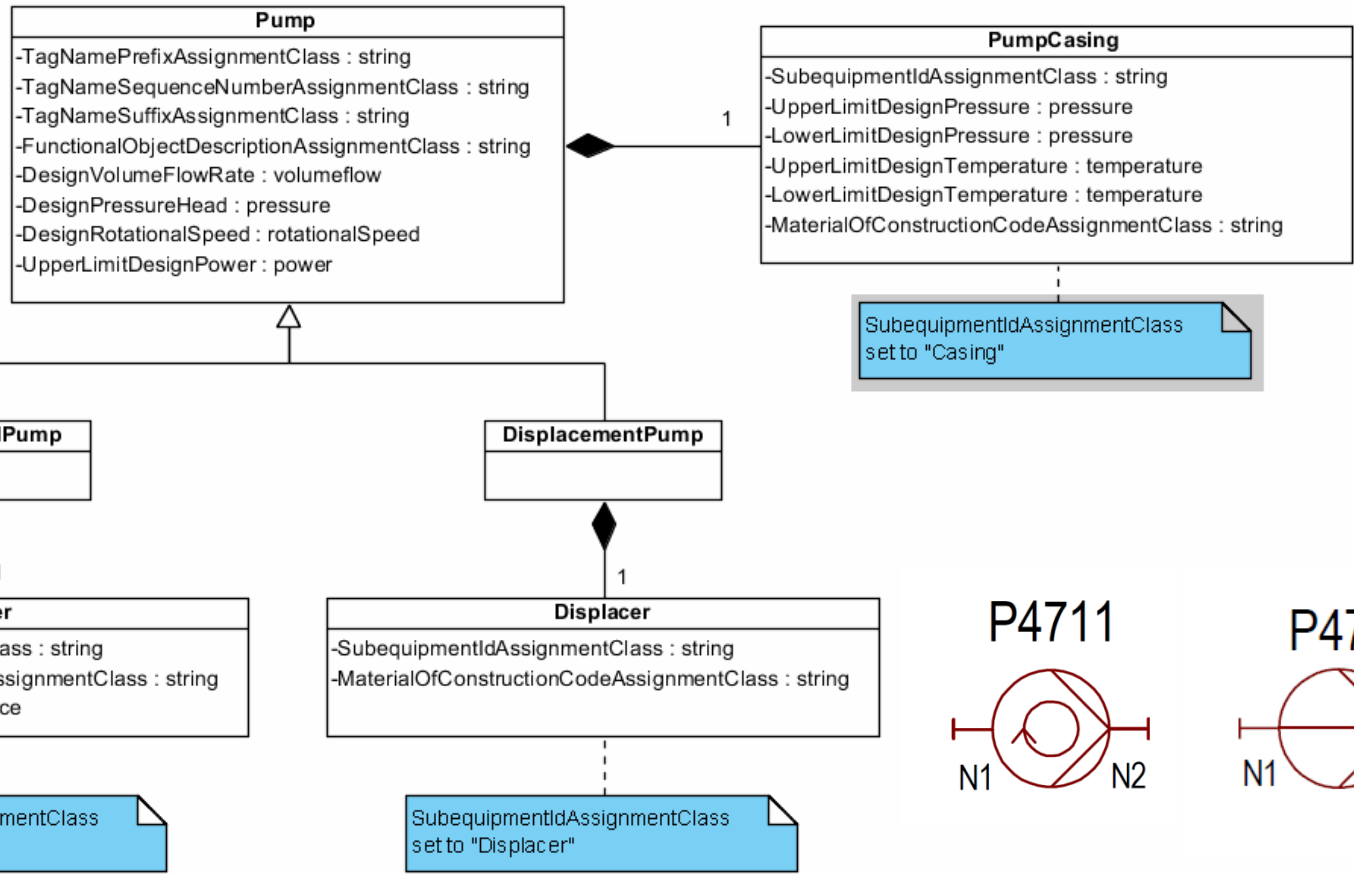


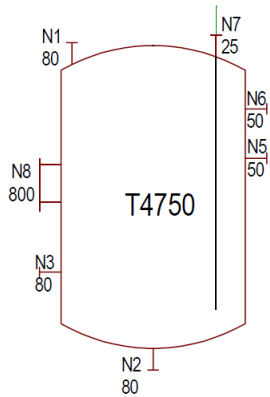
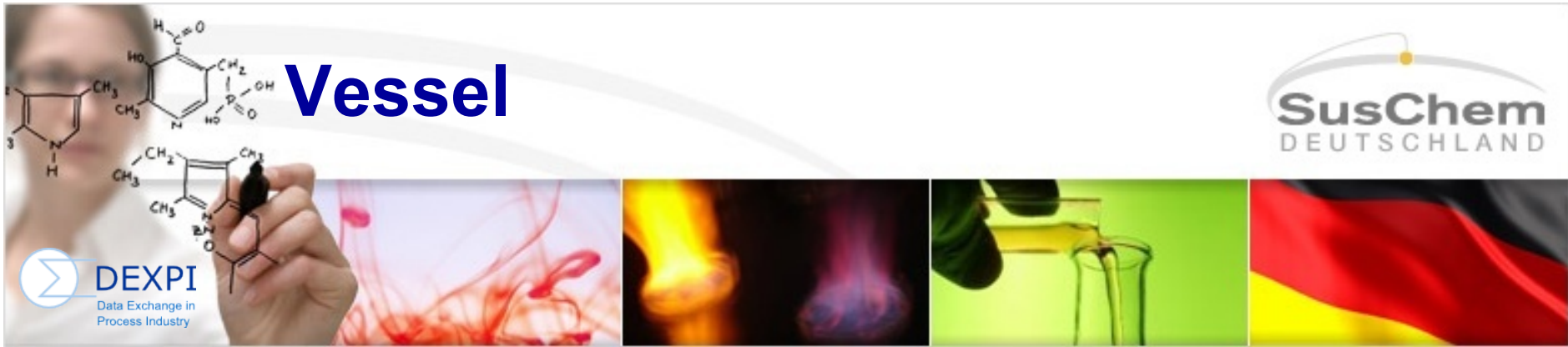
Decomposition



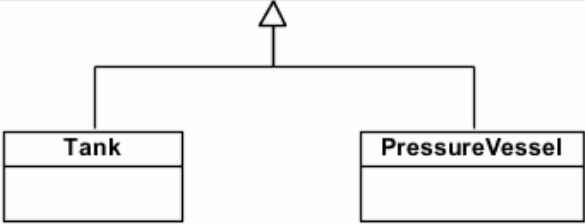
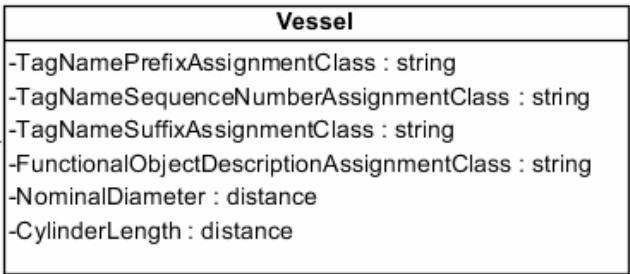


Pump

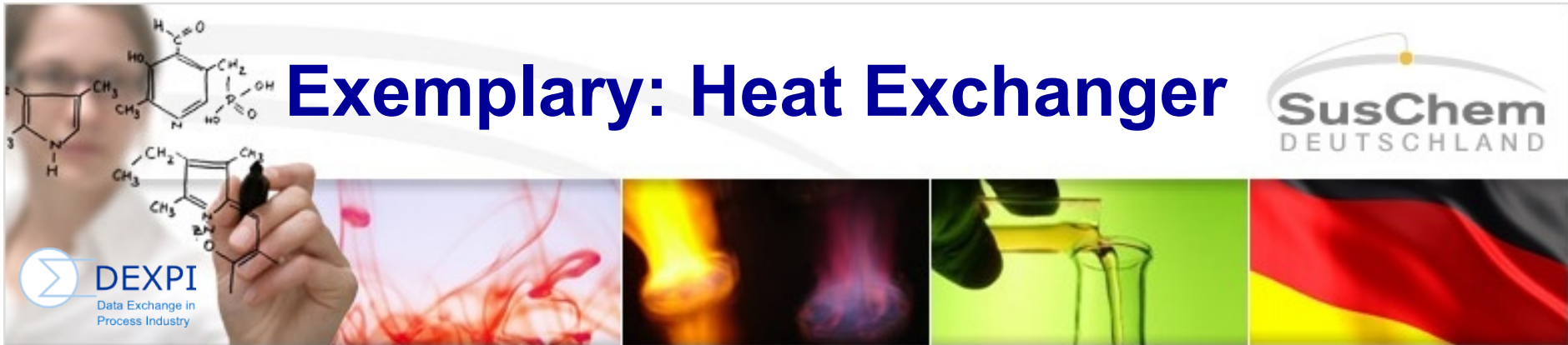




Note: Assumption of a cylindrical vessel.

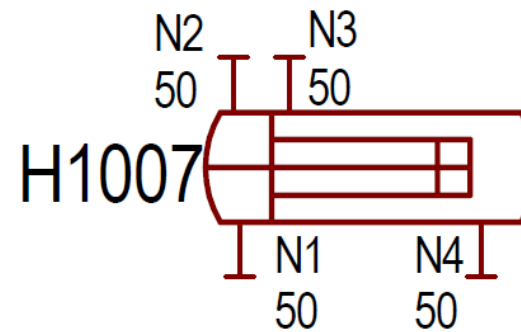


SubequipmentIdAssignmentClass set as specified by user

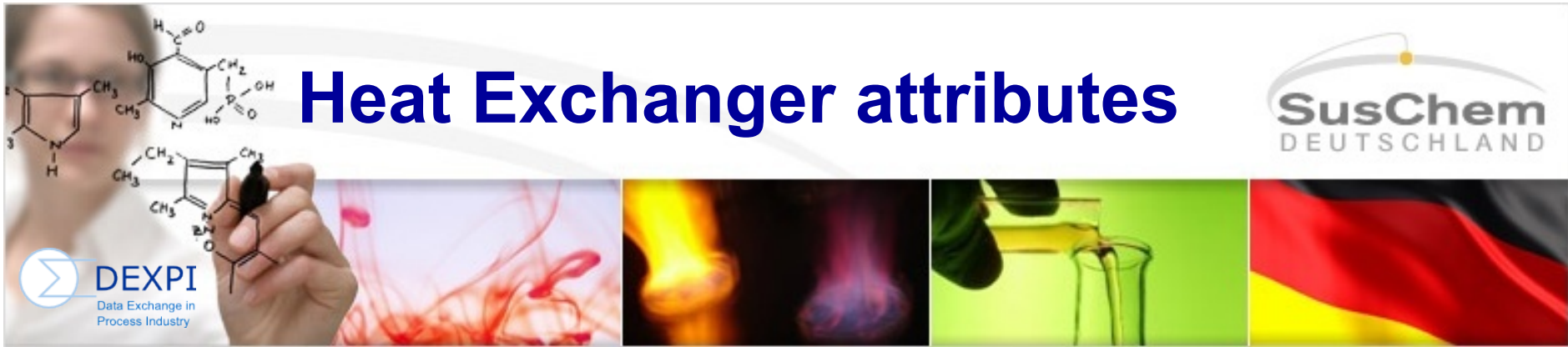


Exemplary: Heat Exchanger

Here:
Shell and Tube Heat Exchanger



Ident	H1007	
Design Press. min. Chamber 1 / 2	-1 barg	-1 barg
Design Press. max. Chamber 1 / 2	60 barg	30 barg
Design Temp. min. Chamber 1 / 2	-45 °C	-45 °C
Design Temp. max. Chamber 1 / 2	100 °C	100 °C
Design Duty / Design Heat Transfer Area	313 kW	46,8 m ²
Nominal Diameter / Tube Length	DN 800	2200 mm
Material Tubes / Material Shell	1.4306	1.4308



Heat Exchanger attributes

- Specifications by the DEXPI group:
 - Tag Name (e.g. „H1007“)
 - Tag Name Prefix („H“)
 - Tag Name Sequence Number („1007“)
 - Tag Name Suffix („“)
 - Description
 - Flow Rate
 - Transfer Area

HeatExchanger
-TagNamePrefixAssignmentClass : string
-TagNameSequenceNumberAssignmentClass : string
-TagNameSuffixAssignmentClass : string
-FunctionalObjectDescriptionAssignmentClass : string
-DesignHeatFlowRate : power
-DesignHeatTransferArea : area



- FunctionalObjectDescriptionAssignmentClass

- NominalDiameter

→ <http://posccaesar.org/rdl/RDS366794>



- TagNamePrefixAssignmentClass

- TagNameSequenceNumberAssignmentClass

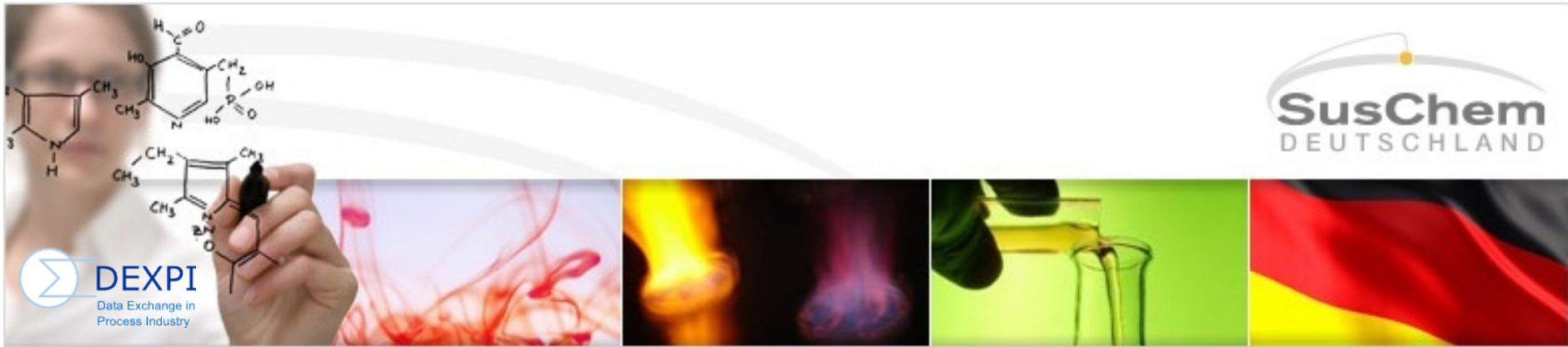
- TagNameSuffixAssignmentClass

- DesignHeatFlowRate

- DesignHeatTransferArea

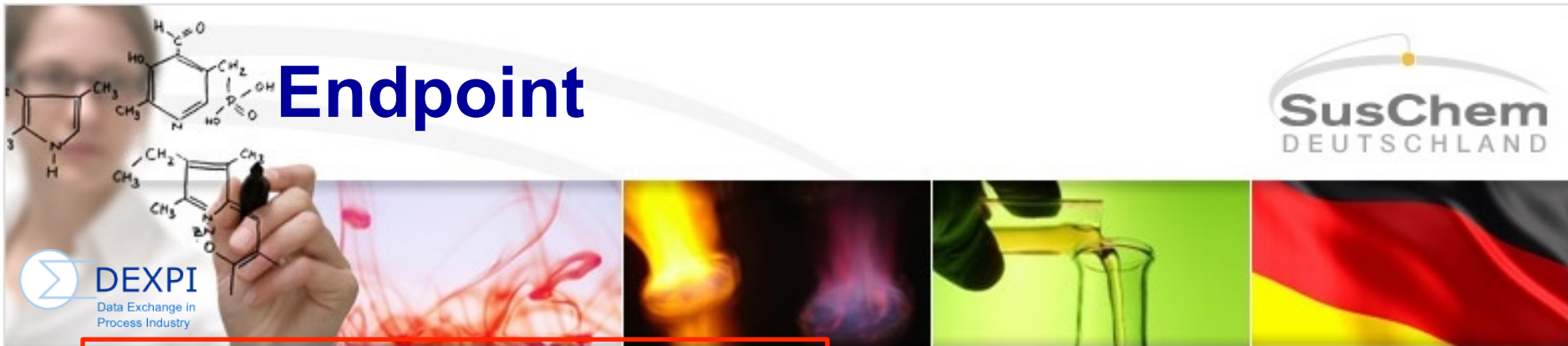
→ <http://sandbox.dexpi.org/rdl/DesignHeatTransferArea>





Solution for missing attributes:

THE DEXPI SANDBOX



Endpoint

SusChem
DEUTSCHLAND

DEXPI
Data Exchange in
Process Industry

- <http://endpoint.dexpi.org>

Firefox - Fuseki - A SPARQL 1.1 Server

endpoint.dexpi.org

Server Management

Control Panel

Documentation

[Fuseki documentation](#)

Validators

- [SPARQL query validator](#)
- [SPARQL update validator](#)
- [RDF data validator](#)
- [IRI validator](#)

General SPARQL Service

- [SPARQL query form](#)

Standards

- [SPARQL 1.1 Query](#)
- [SPARQL 1.1 Update](#)
- [SPARQL 1.1 Protocol](#)
- [SPARQL 1.1 Uniform HTTP Protocol for Managing RDF Graphs](#)

Firefox - Fuseki

endpoint.dexpi.org/sparql.tpl

Dataset: /dexpi

SPARQL Query

```
select * where {?s ?p ?o}
```

Output:

XSLT style sheet (blank for none): /xml-to-html.xsl

Force the accept header to text/plain regardless

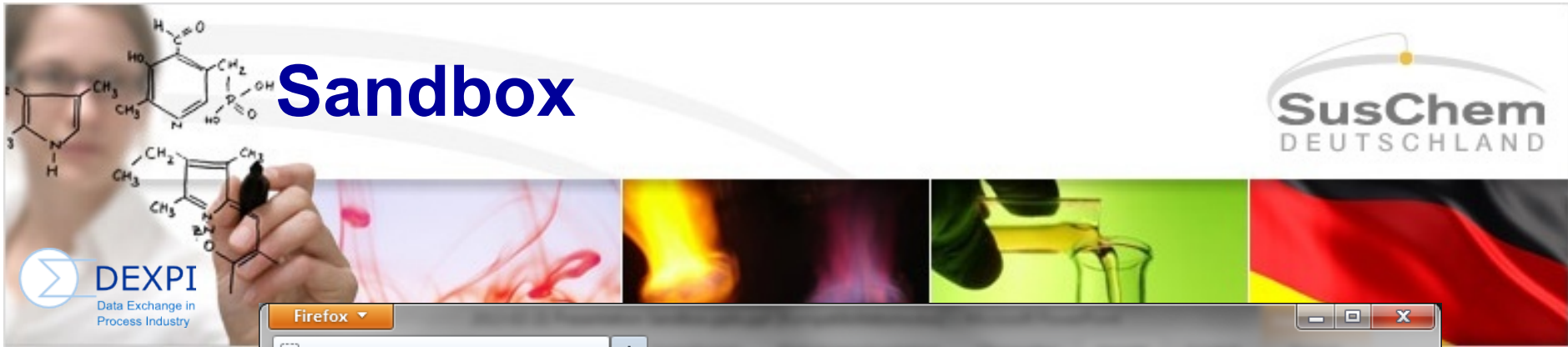
Get Results

Firefox - SPARQLer Query Results

endpoint.dexpi.org/dexpi/query?query=select+*+where+{%3F

SPARQLer Query Results

1	2	3
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstancePhysicalObject>
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://www.w3.org/2000/01/rdf-schema#label>	"DISPLACEMENT PUMP"
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://poscaesar.org/rdf/hasDefinition>	"A pump that makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe."
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://poscaesar.org/rdf/hasDesignation>	"DISPLACEMENT PUMP"
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://sandbox.dexpi.org/rdf/hasLangName>	"DisplacementPump"
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://www.w3.org/2000/01/rdf-schema#comment>	"Definition from Wikipedia."
<http://sandbox.dexpi.org/rdf/DisplacementPump>	<http://www.w3.org/2000/01/rdf-schema#comment>	"Superclass DYNAMIC_PUMP chosen in analogy with CENTRIFUGAL PUMP"
<http://sandbox.dexpi.org/rdf/DesignPressureHeadClassifiedAsDexpiPropertyClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>
<http://sandbox.dexpi.org/rdf/DesignPressureHeadClassifiedAsDexpiPropertyClass>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#hasClassified>	<http://sandbox.dexpi.org/rdf/DesignPressureHead>
<http://sandbox.dexpi.org/rdf/DesignPressureHeadClassifiedAsDexpiPropertyClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>
<http://sandbox.dexpi.org/rdf/DesignPressureHeadClassifiedAsDexpiPropertyClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#SinglePropertyDimension>
<http://sandbox.dexpi.org/rdf/NominalCapacityVolume>	<http://www.w3.org/2000/01/rdf-schema#label>	"NOMINAL CAPACITY VOLUME"
<http://sandbox.dexpi.org/rdf/NominalCapacityVolume>	<http://poscaesar.org/rdf/hasDefinition>	"A nominal volumetric capacity."
<http://sandbox.dexpi.org/rdf/NominalCapacityVolume>	<http://poscaesar.org/rdf/hasDesignation>	"NOMINAL CAPACITY VOLUME"
<http://sandbox.dexpi.org/rdf/NominalCapacityVolume>	<http://sandbox.dexpi.org/rdf/hasLangName>	"NominalCapacityVolume"
<http://sandbox.dexpi.org/rdf/UpperLimitDesignPowerClassifiedAsDexpiPropertyClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>
<http://sandbox.dexpi.org/rdf/UpperLimitDesignPowerClassifiedAsDexpiPropertyClass>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#hasClassified>	<http://sandbox.dexpi.org/rdf/UpperLimitDesignPower>
<http://sandbox.dexpi.org/rdf/UpperLimitDesignPowerClassifiedAsDexpiPropertyClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>
<http://sandbox.dexpi.org/rdf/PlateWidthSubclassORD8361709>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#Specialization>
<http://sandbox.dexpi.org/rdf/PlateWidthSubclassORD8361709>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#hasSubclass>	<http://sandbox.dexpi.org/rdf/PlateWidth>
<http://sandbox.dexpi.org/rdf/PlateWidthSubclassORD8361709>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#Superclass>
<http://sandbox.dexpi.org/rdf/TagNameSequenceNumberAssignmentClassClassifiedAsDexpiIdentificationClassOfClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>
<http://sandbox.dexpi.org/rdf/TagNameSequenceNumberAssignmentClassClassifiedAsDexpiIdentificationClassOfClass>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#hasClassified>	<http://sandbox.dexpi.org/rdf/TagNameSequenceNumberAssignmentClass>
<http://sandbox.dexpi.org/rdf/TagNameSequenceNumberAssignmentClassClassifiedAsDexpiIdentificationClassOfClass>	<http://www.w3.org/1999/02/22-rdf-syntax-ns#type>	<http://rdfs.poscaesar.org/2008/02/OWL-ISO-15926-2_2003#ClassOfInstance>



Firefox

DESIGN HEAT TRANSFER AREA | DEXPI - ...

sandbox.dexpi.org/rdl/page/DesignHeatTransferArea

Google

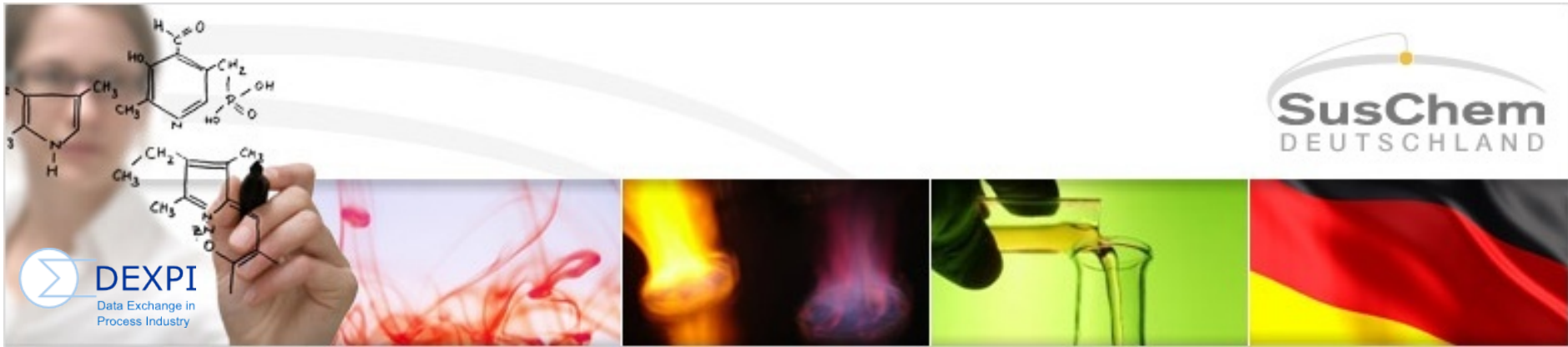
DEXPI Data Exchange in Process Industry
 A WORKING PARTY OF PROCESS NET AN INITIATIVE OF DECHEMA AND VDI-GVC
 SusChem DEUTSCHLAND

DESIGN HEAT TRANSFER AREA at DEXPI - Data EXchange within the Process Industry

<http://sandbox.dexpi.org/rdl/DesignHeatTransferArea>

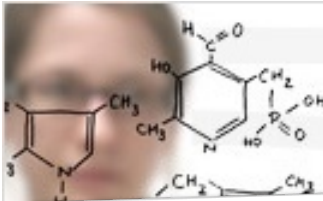
Property	Value
is p2:hasClassified of	■ dexpi:DesignHeatTransferAreaClassifiedAsDexpiPropertyClass
RDL:hasDefinition	■ An area that is available for heat transfer by design.
RDL:hasDesignation	■ DESIGN HEAT TRANSFER AREA
dexpi:hasMangledName	■ DesignHeatTransferArea
is p2:hasSubclass of	■ dexpi:DesignHeatTransferAreaSubclassOfRDS14119225
rdfs:label	■ DESIGN HEAT TRANSFER AREA
rdf:type	■ p2:SinglePropertyDimension

This page shows information obtained from the SPARQL endpoint at <http://sandbox.dexpi.org:3030/dexpi/query>.
[As Turtle](#) | [As RDF/XML](#)



XMpLant and ISO-OWL

APPLICATION OF DEXPI INFORMATION MODELS

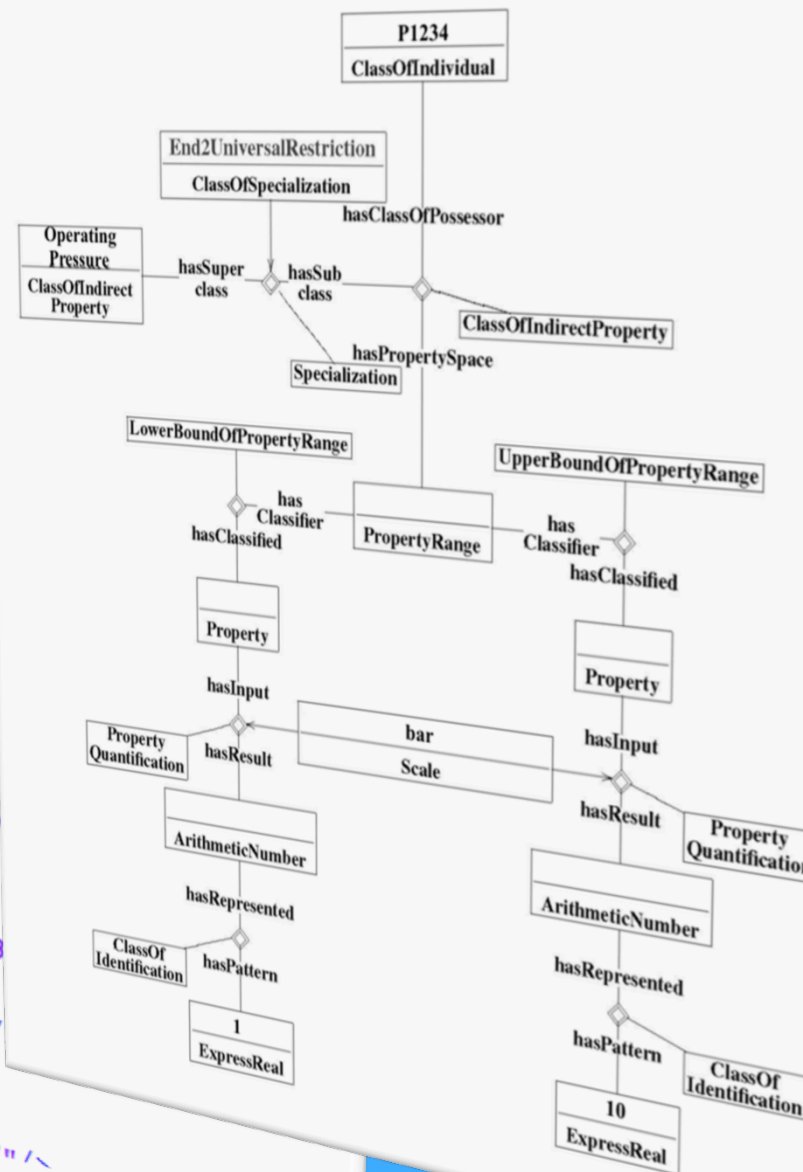


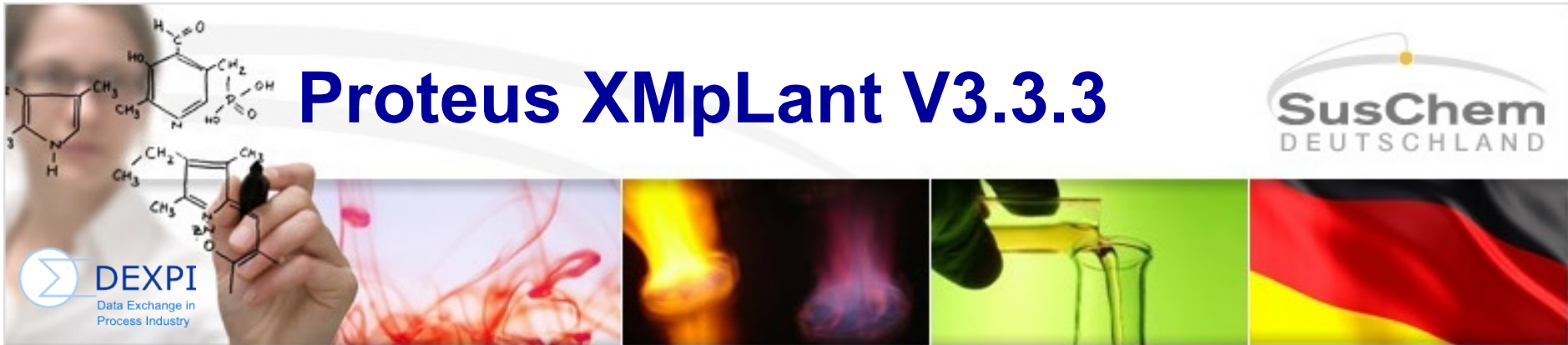
ISO-OWL, Part 7/8

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<rdf:type rdf:resource="http://tpl.rdlfacade.org/data#R336126745" />
<tpl:R56806886394 rdf:resource="http://rd1.rdlfacade.org/data#R336126745" />
<tpl:R65789235245 rdf:datatype="http://www.w3.org/2001/XMLSchema#integer" />
</tpl:R65789235245>
<tpl:R11450580697 rdf:resource="http://www.bnode.org#hDlexajF633" />
<tpl:R10528152386 rdf:resource="http://rd1.rdlfacade.org/data#R10528152386" />
</owl:Thing>
<owl:Thing rdf:about="http://www.bnode.org#hDlexajF605">
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  <tpl:R56806886394 rdf:resource="http://rd1.rdlfacade.org/data#R336126745" />
  <tpl:R65789235245 rdf:datatype="http://www.w3.org/2001/XMLSchema#integer" />
  </tpl:R65789235245>
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  <tpl:R54167847248 rdf:resource="http://www.ex.org#W101" />
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</owl:Thing>
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  <tpl:R56806886394 rdf:resource="http://rd1.rdlfacade.org/data#R31707644307" />
  <tpl:R65789235245 rdf:datatype="http://www.w3.org/2001/XMLSchema#integer" />
  </tpl:R65789235245>
  <tpl:R11450580697 rdf:resource="http://www.ex.org#B102" />
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</owl:Thing>

```





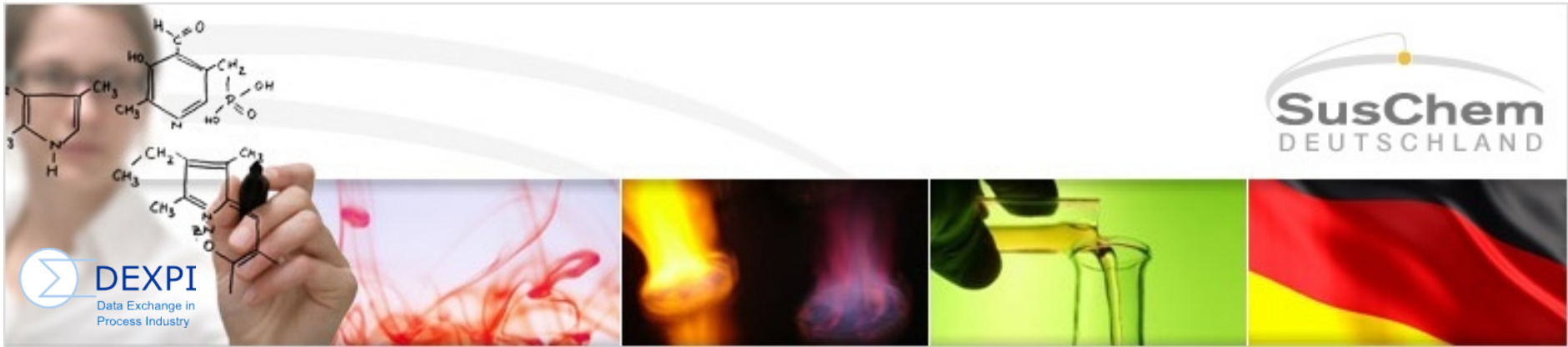
- Several predefined attributes

```
<NominalDiameter Value="80.0" Units="mm" />
```

- Non-predefined attributes as „generic attributes“:

```
<GenericAttribute
Name="FunctionalObjectDescriptionAssignmentClass"
Value="Prozessgaskühler"
Format="string"
URI="http://posccaesar.org/rdl/RDS2101566251"/>
```

```
<GenericAttribute
Name="DesignHeatFlowRate"
Value="313"
Format="double"
Units="Kilowatt"
URI="http://sandbox.dexpi.org/rdl/DesignHeatFlowRate"/>
```



Output of the

VALIDATION TOOL



DEXPI - Data EXchange in the Process Industry

Validator Prototype

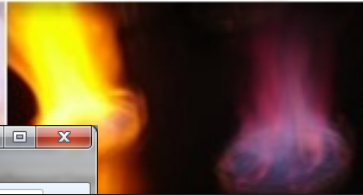
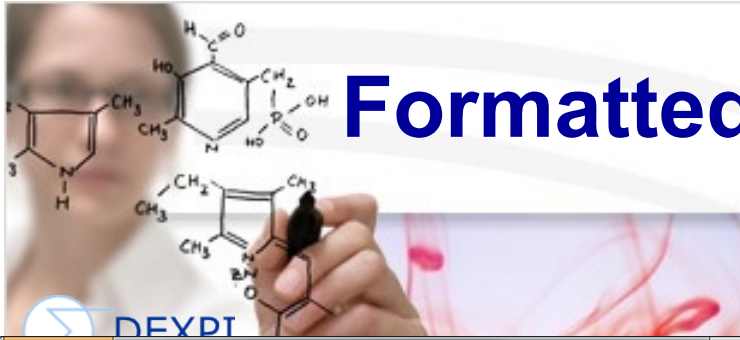
DEXPI Version: 0.6 ▾

XMpLant Input File:

Output: Validation Report ▾

For more information see: www.dexpi.org

Formatted Report



Firefox | http://tools.dexpi.org/validator/

Validation Report

File	/tmp/validator/session_20130306153837687/uploaded_file.xml
Originating System	
Date	2013-03-04 11:59:44
Dexpi Model Version	0.6
Validation Date	2013-03-06 15:38:38
Validity	VALID

Validation Results

Equipments		
Equipment	Validity	Reason
Tank	VALID	
DisplacementPump	VALID	
PlateAndShellHeatExchanger	VALID	
Vessel	ABSENT	Equipment not defined;
HeatExchanger	ABSENT	Equipment not defined;
ShellAndTubeHeatExchanger	VALID	
CentrifugalPump	VALID	

Firefox | http://tools.dexpi.org/validator/#N65948

Validation Report

File	/tmp/validator/session_2013030615355556/uploaded_file.xml
Originating System	
Date	2013-02-27 20:31:39
Dexpi Model Version	0.6
Validation Date	2013-03-06 15:35:55
Validity	INVALID

Validation Results

Equipments		
Equipment	Validity	Reason
HeatExchanger	ABSENT	Equipment not defined;
CentrifugalPump	VALID	
Vessel	ABSENT	Equipment not defined;
DisplacementPump	VALID	
PlateAndShellHeatExchanger	INVALID	
Tank	VALID	
ShellAndTubeHeatExchanger	VALID	

Tank

SubEquip	Attribute	Validity Type
-	TankNamePrefixAssignmentClass	VALID
-	TankNameSequenceNumberAssignmentClass	VALID
-	TankNameSuffixAssignmentClass	VALID
-	FunctionalObjectDescriptionAssignmentClass	VALID
-	NominalDiameter	VALID
-	CylinderLength	VALID
Chamber	-	VALID
-	SubequipmentIdAssignmentClass	VALID
-	UpperLimitDesignPressure	VALID
-	LowerLimitDesignPressure	VALID
-	UpperLimitDesignTemperature	VALID
-	LowerLimitDesignTemperature	VALID
-	NominalCapacityVolume	VALID
-	MaterialOfConstructionCodeAssignmentClass	VALID
Chamber	-	VALID
-	SubequipmentIdAssignmentClass	VALID
-	UpperLimitDesignPressure	VALID

SubEquip	Attribute	Validity Type
-	TankNamePrefixAssignmentClass	VALID
-	TankNameSequenceNumberAssignmentClass	VALID
-	TankNameSuffixAssignmentClass	VALID
-	FunctionalObjectDescriptionAssignmentClass	VALID
-	DesignVolumeFlowRate	VALID
-	DesignPressureHead	VALID
-	DesignRotationalSpeed	VALID
-	UpperLimitDesignPower	VALID
Impeller	-	VALID
-	SubequipmentIdAssignmentClass	VALID
-	MaterialOfConstructionCodeAssignmentClass	VALID
-	DesignDiameterWheel	VALID
-	UpperLimitDesignTemperature	VALID
-	LowerLimitDesignTemperature	VALID
PumpCasing	-	VALID
-	SubequipmentIdAssignmentClass	VALID
-	UpperLimitDesignPressure	VALID

PlateAndShellHeatExchanger

SubEquip	Attribute	Validity Type	Reason
-	TankNamePrefixAssignmentClass	VALID	
-	TankNameSequenceNumberAssignmentClass	VALID	
-	TankNameSuffixAssignmentClass	VALID	
-	FunctionalObjectDescriptionAssignmentClass	VALID	
-	DesignHeatFlowRate	VALID	
-	DesignHeatTransferArea	VALID	
-	MaterialOfConstructionCodeAssignmentClass	VALID	
-	PlateHeight	VALID	
-	PlateWidth	VALID	
Chamber	-	INVALID	
-	SubequipmentIdAssignmentClass	VALID	
-	UpperLimitDesignPressure	VALID	
-	LowerLimitDesignPressure	VALID	
-	UpperLimitDesignTemperature	VALID	
-	LowerLimitDesignTemperature	VALID	
-	NominalCapacityVolume	INVALID	Could not parse ' to 'double'.

XML Report

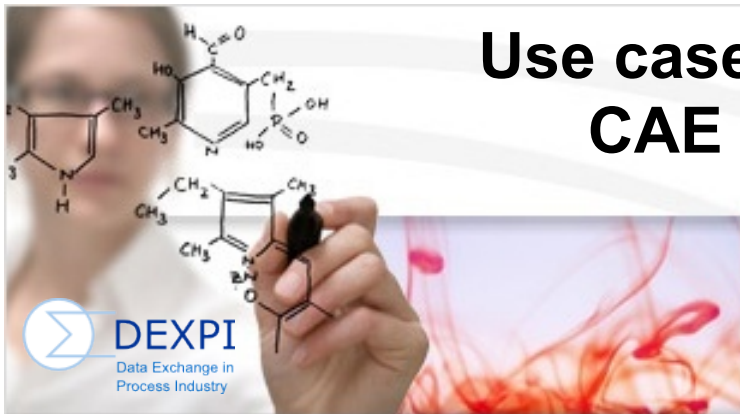



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1  <?xml version="1.0" encoding="UTF-8" standalone="no"?>
2  <?xml-stylesheet type="text/xsl" href="xslt 3.xsl"?>
3  <ValidationReport>
4  <InputFileName>company_example_02.xml</InputFileName>
5  <OriginatingSystem>Super PID Software</OriginatingSystem>
6  <InputFileDateTime>2013-02-06 16:41:29</InputFileDateTime>
7  <DexpiModelVersion>0.5</DexpiModelVersion>
8  <ValidationDateTime>2013-02-18 18:59:33</ValidationDateTime>
9  <Validity>VALID</Validity>
10 <ValidationResults>
11 <ValidationResult>
12 <DexpiElement>HeatExchanger</DexpiElement>
13 <ValidityType>ABSENT</ValidityType>
14 <ResultType>EQUIPMENT</ResultType>
15 <Reason>Equipment not defined; </Reason>
16 </ValidationResult>
17 <ValidationResult>
18 <DexpiElement>DisplacementPump</DexpiElement>
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21 <Reason/>
22 </ValidationResult>
23 <DexpiElement>g:TagNamePrefix</DexpiElement>
24 <ValidityType>ABSENT</ValidityType>
25 <ResultType>ATTRIBUTE</ResultType>
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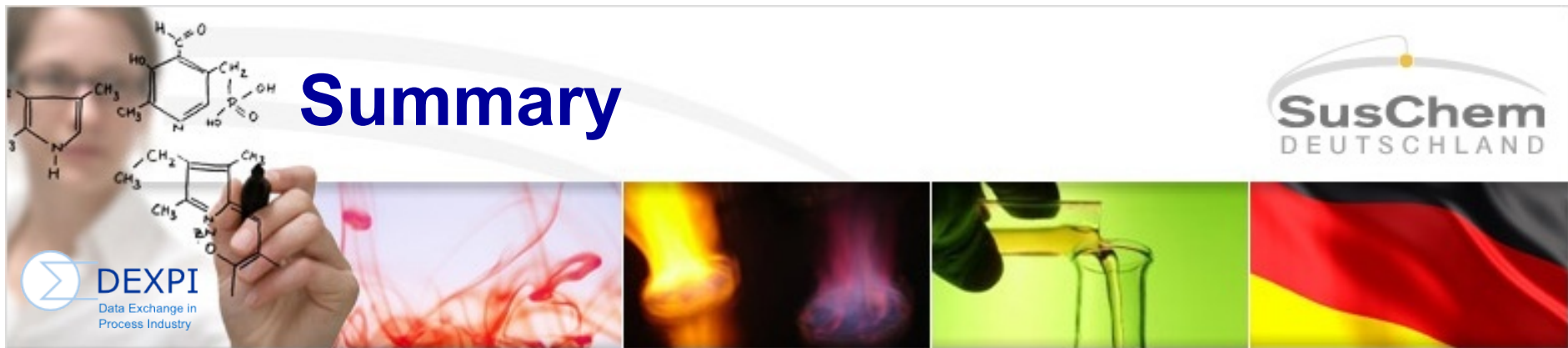
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Use case P&ID exchange – CAE vendor results

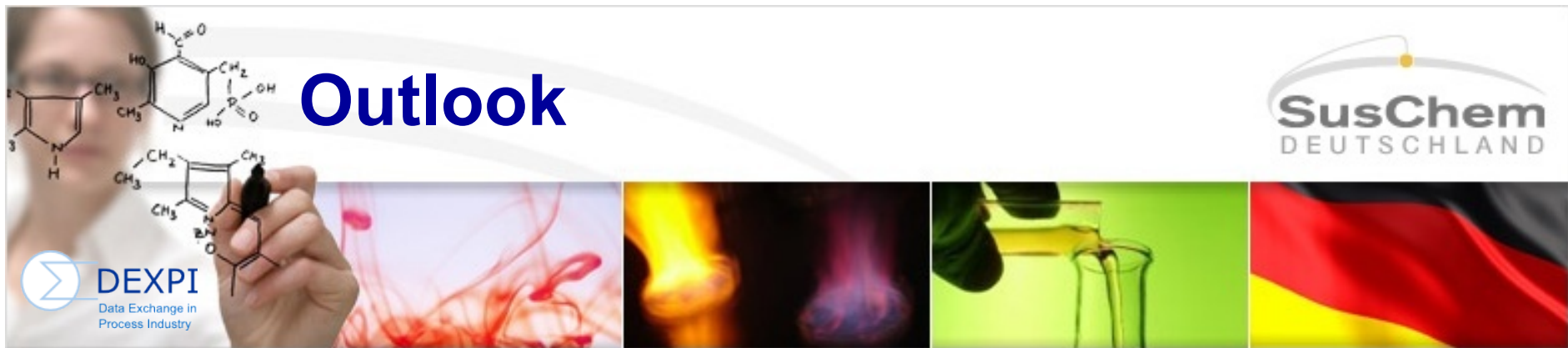


CAE Vendor	Support of DEXPI P&ID model according	Status 2013-03-22
Autodesk®	Proteus / XMpLant schema 3.3.3	✓
AVEVA CONTINUAL PROGRESSION	Proteus / XMpLant schema 3.3.3	✓
 Bentley® Sustaining Infrastructure	ISO Part 7/8 OWL	✓(*)
INTERGRAPH®	Proteus / XMpLant schema 3.3.3	✓
SIEMENS	Proteus / XMpLant schema 3.3.3	✓

(*) graphic part is well under way



- DEXPI group is ISO 15926 ready
- Common information model
 - Is generic
 - Can be used for XMpLant
 - Can be used for ISO-OWL
- Validation tool verifies the exports of CAE vendors



- Validation of ISO-OWL files
- Additional visualization of XMpLant → as SVG
- Expanding models towards life cycle aspects
- Intensify exchange with members of ISO community
- Communicaton / publication of DEXPI results



Thank you for your attention!

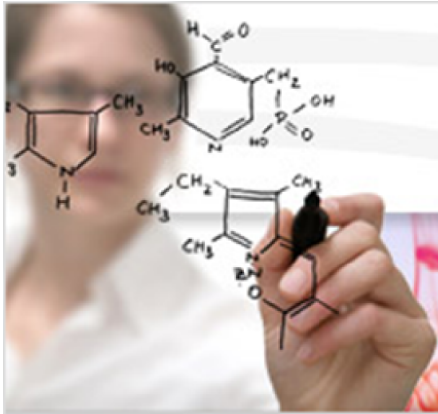
Michael Wiedau

Diplom-Informatiker (FH)

Master of Science in Artificial Intelligence

Lehrstuhl für Prozeßtechnik
Aachener Verfahrenstechnik
RWTH Aachen University





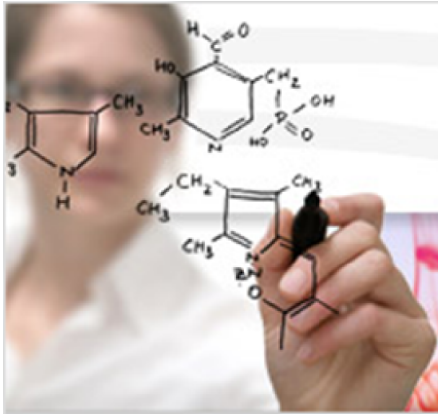
DEXPI Data Exchange in
Process Industry

A WORKING PARTY OF
PROCESSNET
AN INITIATIVE OF DECHEMA AND VDI-GVC





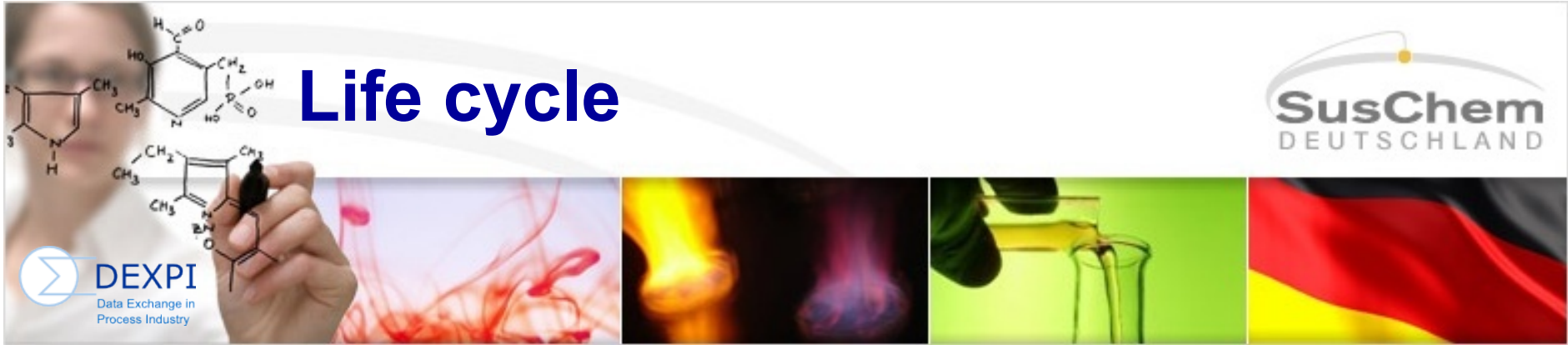
BACKUP



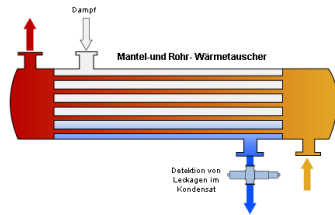
DEXPI Data Exchange in
Process Industry

A WORKING PARTY OF
PROCESSNET
AN INITIATIVE OF DECHEMA AND VDI-GVC

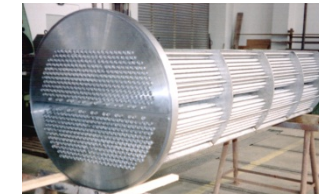




Specification of function in a conceptual phase as in process simulation (Versioning required)



Specification of equipment under a construction aspect as in shop drawings (Versioning required)

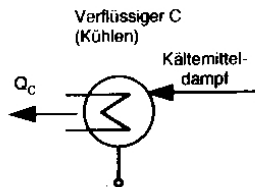


Functional requirements

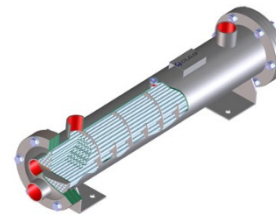
Functional design

Asset specification

Asset operational

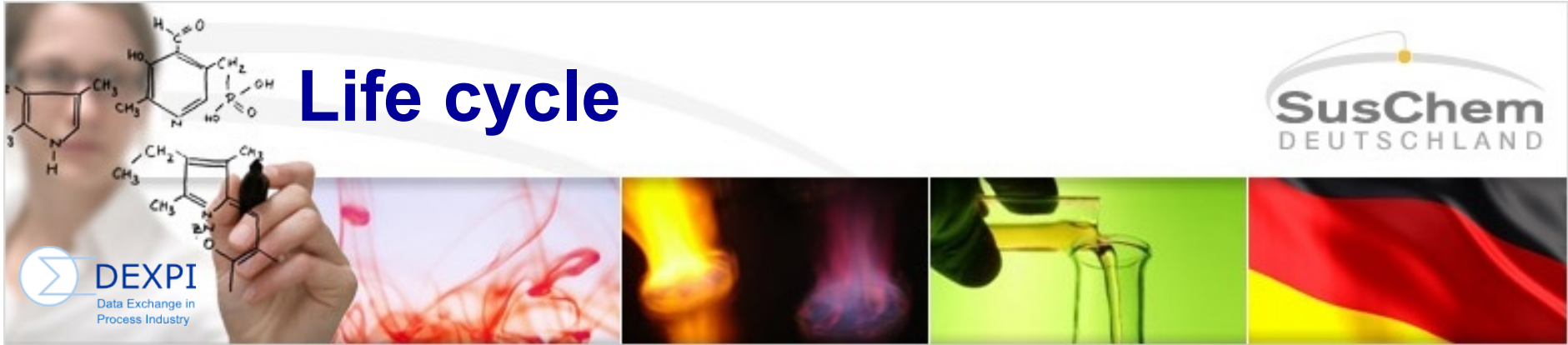


Specification of equipment from a detailed process aspect, e.g. using mathematical models (Versioning required)

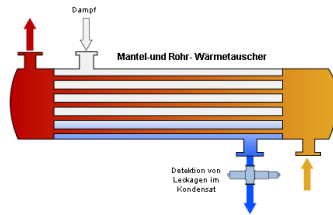


Specification of a physical equipment as built and delivered

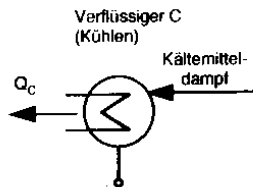
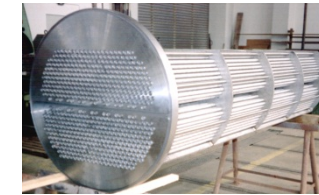




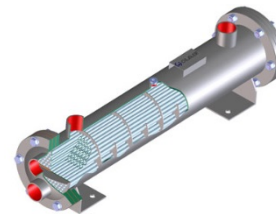
Specification of function in a conceptual phase as in process simulation (Versioning required)



Specification of equipment under a construction aspect as in shop drawings (Versioning required)



Specification of equipment from a detailed process aspect, e.g. using mathematical models (Versioning required)



Specification of a physical equipment as built and delivered

