Classification and Exchange of Industry Standards using OWL Ontologies

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Aibel is a leading service company within the oil, gas and offshore wind industries. We provide our customers with optimal and innovative solutions within engineering, construction, modifications and maintenance throughout a plant's entire life cycle. Aibel has used semantic technologies to support it's business since 2013, and since 2015 the Material Master Data (MMD) ontology and system has been in use for all capital projects. The MMD ontology is based on OWL 2 and uses ISO 15926-14 as upper ontology. Today, MMD consists of 370 domain-specific ontologies, defining a total of 200.000 classes. The Aibel/OntoCommons use case represents a potential future extension of the MMD ontology.

Representing industrial standards as OWL ontologies

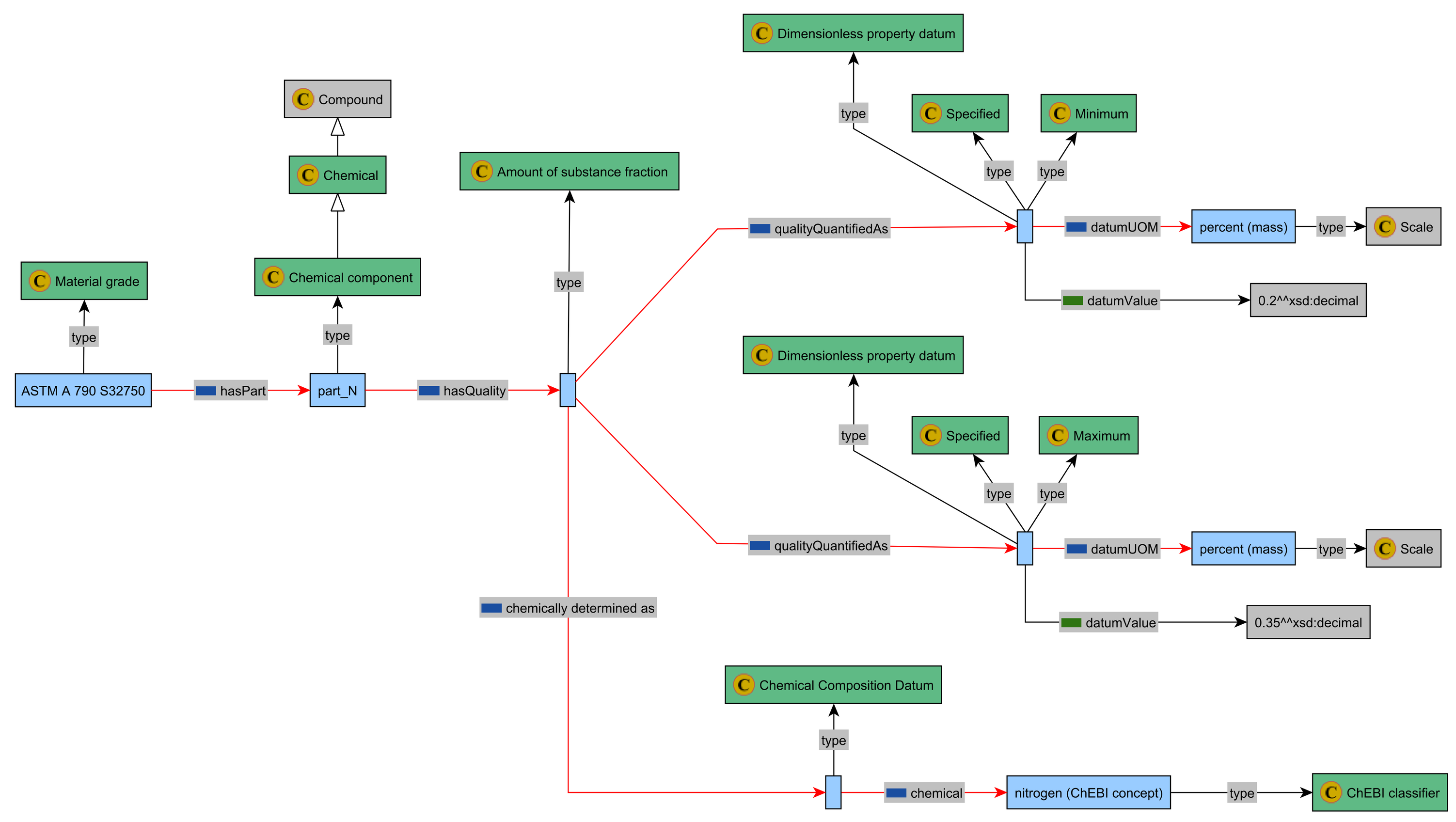
Engineers rely heavily on industrial standards for the specification and design of all engineered artefacts. There is an enormous amount of such standards for materials, dimensions, safety, governmental requirements, and so on. Aibel uses OWL ontologies for organising standards, engineering designs and storehouse inventory. In this use case we translate material grade standards to OWL ontologies.

TABLE 2 Chemical Requirements[A]

UNS Designation[B]	Type[C]	C	Mn	P	S	Si	Ni	Cr	Mo	N	Cu	Others
S31200		0.030	2.00	0.045	0.030	1.00	5.5–6.5	24.0–26.0	1.20–2.00	0.14–0.20	. . .	. . .
S31260		0.030	1.00	0.030	0.030	0.75	5.5–7.5	24.0–26.0	2.5–3.5	0.10–0.30	0.20–0.80	W 0.10–0.50
S31500		0.030	1.20–2.00	0.030	0.030	1.40–2.00	4.2–5.2	18.0–19.0	2.50–3.00	0.05–0.10	. . .	. . .
S31803		0.030	2.00	0.030	0.020	1.00	4.5–6.5	21.0–23.0	2.5–3.5	0.08–0.20	. . .	. . .
S32003		0.030	2.00	0.030	0.020	1.00	3.0–4.0	19.5-22.5	1.50–2.00	0.14–0.20	. . .	. . .
S32101		0.040	4.0–6.0	0.040	0.030	1.00	1.35–1.70	21.0–22.0	0.10–0.80	0.20–0.25	0.10–0.80	. . .
S32202		0.030	2.00	0.040	0.010	1.00	1.00–2.80	21.5–24.0	0.45	0.18–0.26	. . .	. . .
S32205	2205	0.030	2.00	0.030	0.020	1.00	4.5–6.5	22.0–23.0	3.0–3.5	0.14–0.20	. . .	. . .
S32304	2304	0.030	2.50	0.040	0.040	1.00	3.0–5.5	21.5–24.5	0.05–0.60	0.05–0.20	0.05–0.60	. . .
S32506		0.030	1.00	0.040	0.015	0.90	5.5–7.2	24.0–26.0	3.0–3.5	0.08–0.20	. . .	W 0.05–0.30
S32520		0.030	1.5	0.035	0.020	0.80	5.5–8.0	24.0–26.0	3.0–5.0	0.20–0.35	0.5–3.00	. . .
S32550	255	0.04	1.50	0.040	0.030	1.00	4.5–6.5	24.0–27.0	2.9–3.9	0.10–0.25	1.50–2.50	. . .
S32707		0.030	1.50	0.035	0.010	0.50	5.5–9.5	26.0–29.0	4.0–5.0	0.30–0.50	1.0	Co 0.5–2.0

Ontology patterns following ISO 15926-14 upper ontology

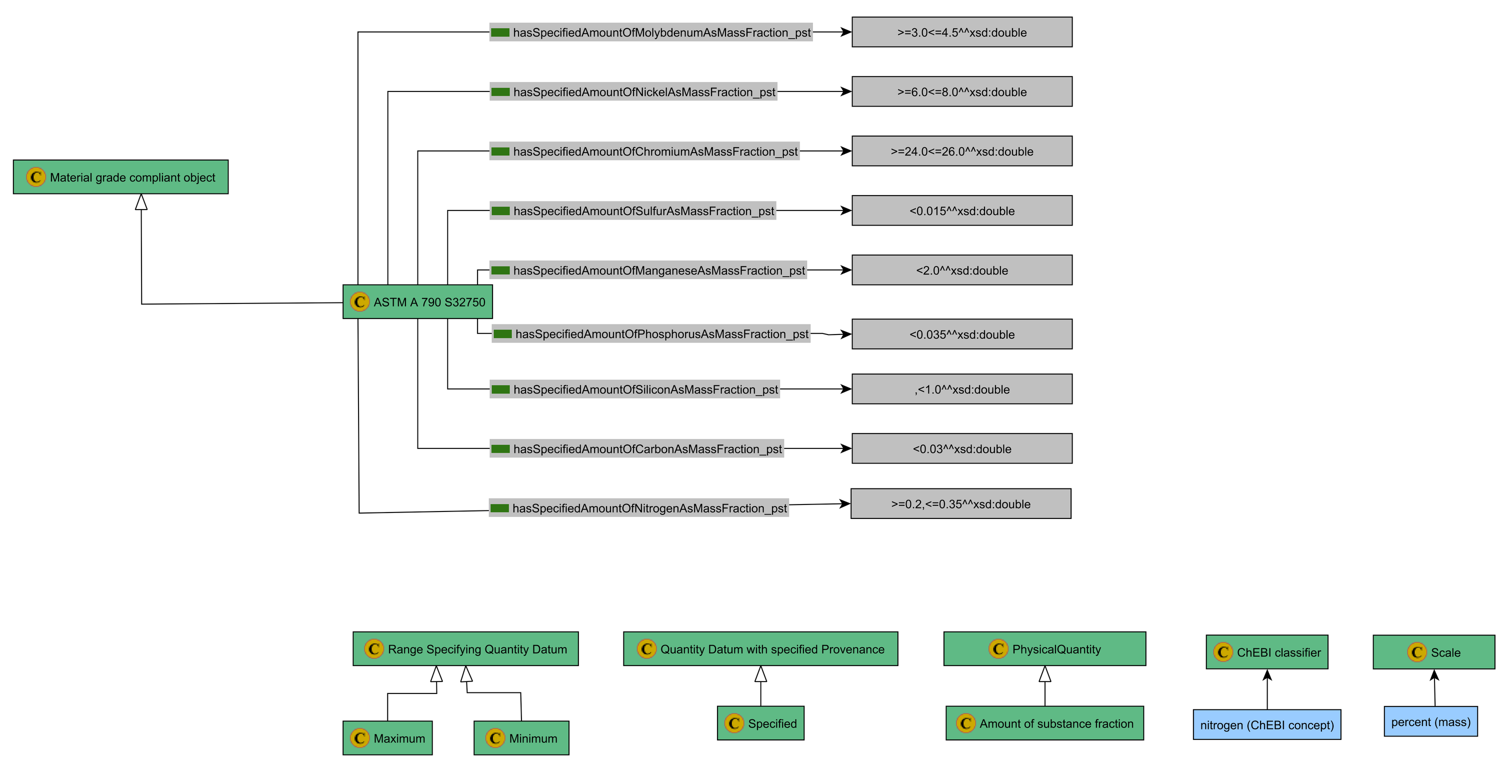
Material grades are represented as OWL individuals using a rich pattern for qualities and datums as described by ISO 15926-14. The rich format is suitable for data exchange and further processing.



$X101211334 \sqsubseteq \forall hasSpecifiedAmountOfNitrogenAsMassFraction\_pst.\ \text{xsd:double}[\geq 0.2, \leq 0.35]$

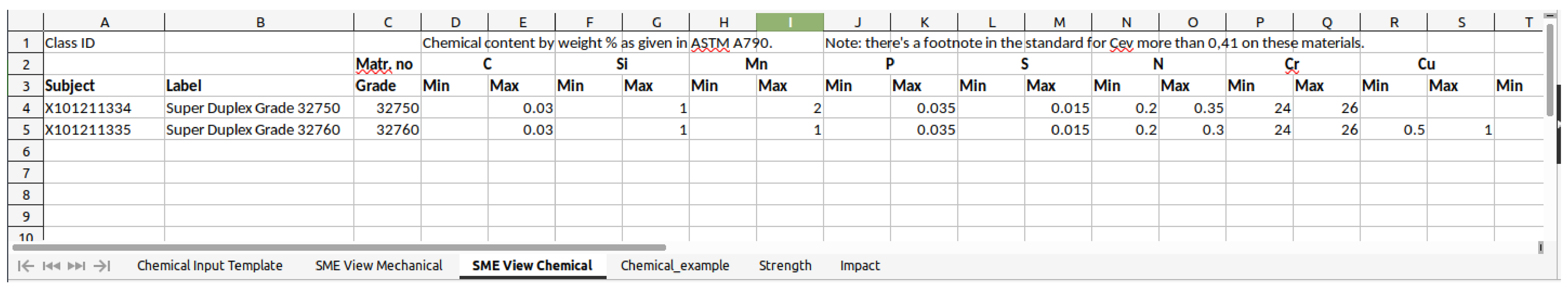
Generated OWL class representation for classification

From the rich format, a simpler format that is better suited for OWL reasoning is generated. Material composition is represented using class restrictions on generated "shortcut" datatype properties.



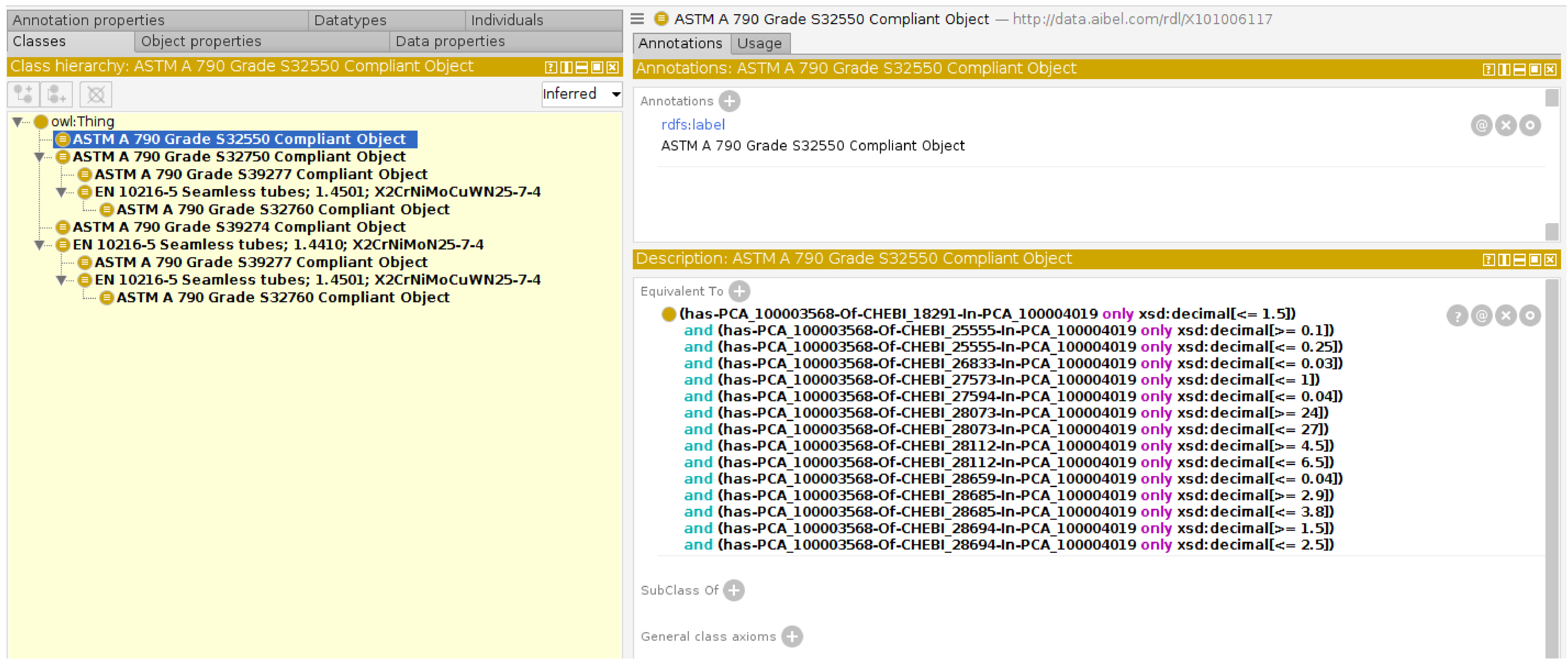
Data input by domain experts using simple spreadsheets

Data is provided by SMEs using simple spreadsheets formats prepared by ontology experts.



Exploit ontology reasoning for discovering overlapping industry standard specifications

By reasoning over the OWL class representation we can discover relationships between different material grades and material grade standards.



Data transformation pipeline driven by Reasonable Ontology Templates (OTTR)

OTTR (http://ottr.xyz) is language and framework for representing and instantiating modelling patterns. We use OTTR to represent the modelling patterns as OTTR templates and use the OTTR framework to translate the spreadsheet data into different OWL representations:

Spreadsheet data —tabOTTR⟶ OWL ontology of material grades —bOTTR⟶ OWL ontology for classification

OTTR template representing a pattern for chemical composition:

```
a:ChemicalComposition[
    ottr:IRI ?materialGrade,
    ? xsd:string ?materialLabel,
    ottr:IRI ?chemicalElement,
    xsd:decimal ?value,
    ottr:IRI ?physicalQuantity,
    ottr:IRI ?scale, ottr:IRI ?provenance, ottr:IRI ?range
] :: {
  o-rdfs:ResourceDescription(?materialGrade, ?materialLabel, none, none, none),
  ottr:Triple(?materialGrade, p14:hasPhysicalQuantity, _:quantity),
  o-rdf:Type( _:quantity, ?physicalQuantity),
  ottr:Triple( _:quantity, p14:hasQuality, _:quality),
  ottr:Triple( _:quality, p14:chemicallyDeterminedAs, ?chemicalElement),
  a:Datum(_:quantity, p14:qualityQuantifiedAs, ?provenance, ?range, none, none, ?value, ?scale)
} .
```

Impact

- **Benefits.** The MMD ontology and system provide a significant increase in the quality of engineering data used for design and procurement in EPC projects. In particular, duplicate component types are completely eliminated, resulting in reduced ordering of incorrect components and better utilization of warehouse stock across projects.
- The Aibel/OntoCommons use case has the potential to further increase the business benefits gained from MMD by providing a more fine-grained break-down of the details of material grade definitions. This can be utilized to find overlap between grade definitions.
- **Challenges/obstacles** for utilization of semantic technologies are lack of tool support, scalability of ontology development, lack of proven work methods for collaborative ontology development.

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