

Digital Standards and Specifications Built on QIF Rules

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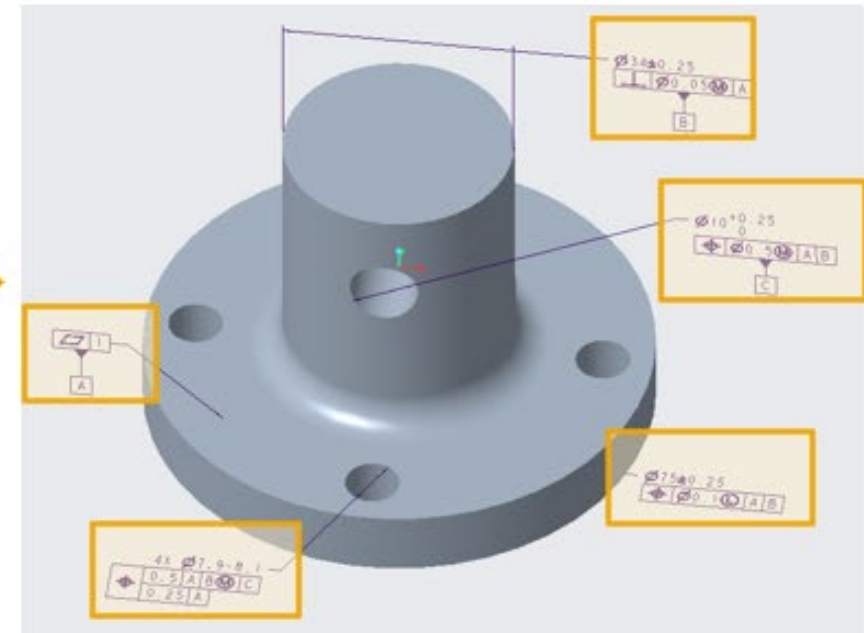
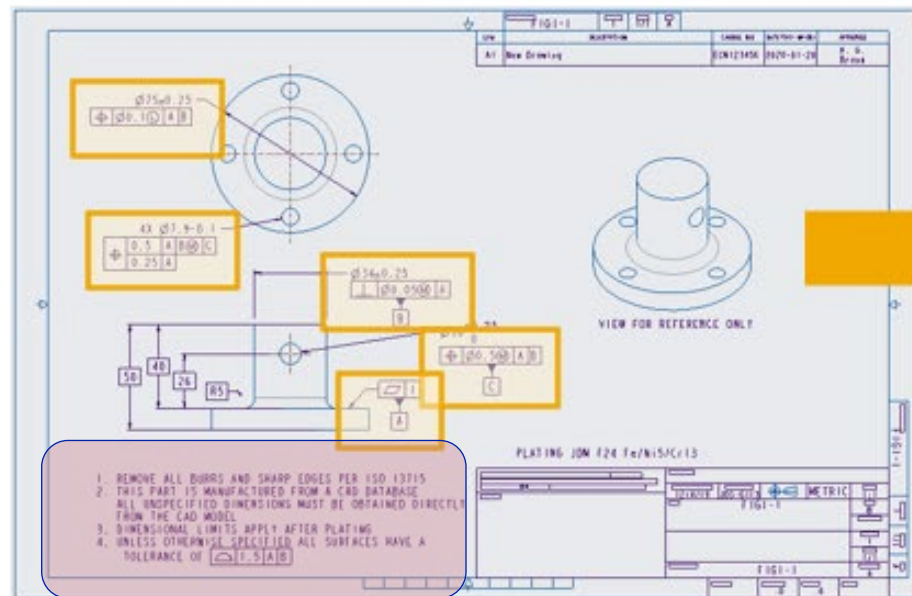
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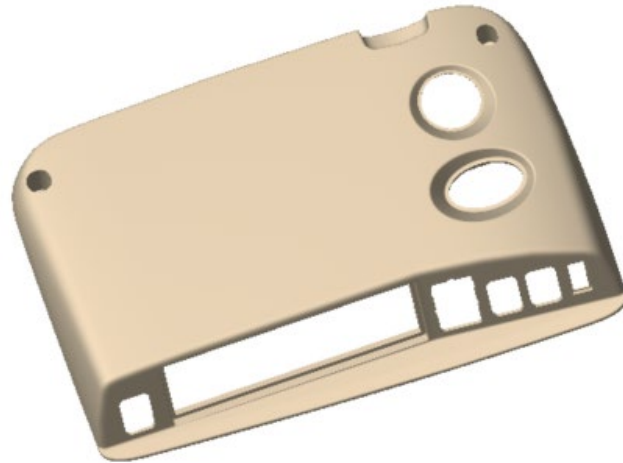
Digital Standards and MBD



Requirements called out in notes are an untapped source of MBD

Machine-Readability Problem

Tolerancing standard notes are not machine-readable



UNLESS OTHERWISE SPECIFIED
REQUIREMENTS PER JDS-D41
TOLERANCE: GENERAL

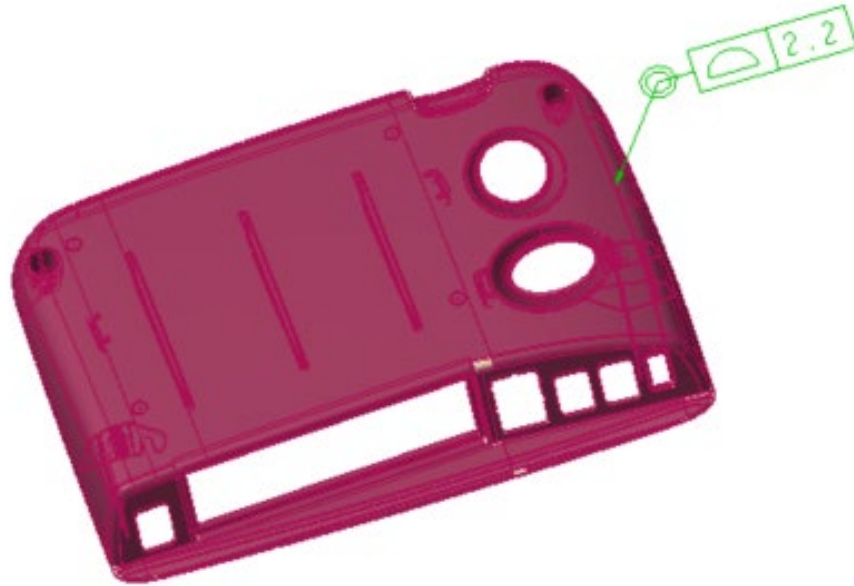
How can standardized tolerances be transformed into MBD?



Machine-Interpretable Language

The solution?

**A machine-interpretable digital standards language
that creates specifications that software can automatically act upon.**



What is a Specification?

In the context of this presentation – a SPECIFICATION is:

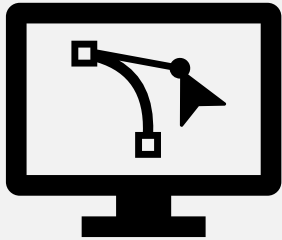
An external document referenced by a Product Definition that creates additional accountable characteristics or levies other requirements.

Common Examples

- General Machining Tolerances
- Welding
- Commodity Specification Machining
- Shot Peening
- Material Specs
- Part Marking
- Non-Destructive Evaluation

Bill of Characteristics

Model-Based Definition



Part Bill of Characteristics



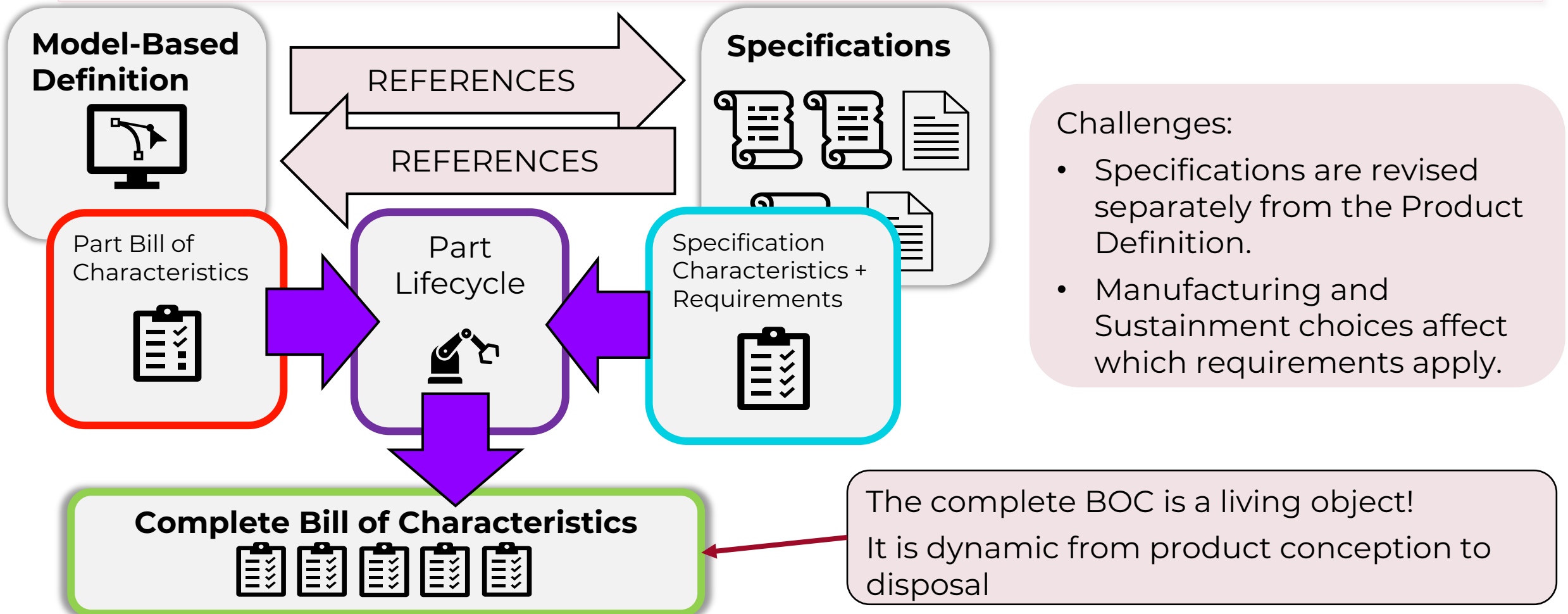
Characteristics are the cornerstone of a Model-Based Enterprise

When is the Bill of Characteristics complete?

Characteristic Traceability usually refers to **Product Definition** characteristics.

We balloon the drawing and get a static Bill of Characteristics.

Specifications in a Bill of Characteristics



SCENARIO:

Specification Language Depends on Part Geometry or Attributes

Machining Requirements

Unless otherwise specified, all diameters shown concentric shall meet runout tolerances per Table X-X

Unless otherwise specified, break edges in shot peened areas shall be .xx +/- .xx prior to shot peen

Process-Dependent Requirements

If welding on a pressure vessel, requirements per Section X.X apply

Commodity-Specific Requirements

For rotating parts, requirements per Section X.X apply

SCENARIO: General Note Overrides Specification

Model-Based Definition

MBD02_GENERAL_NOTES

HEAT TREAT PER PXTFXX EXCEPT:

- A) TEMPERATURE TO BE 1200 +/- 50°F
- B) COOL AT 100°F PER MINUTE UNTIL TEMPERATURE IS BELOW 300°F
- C) ...

SPECIFICATION PXTFXX

X.X.X HEAT TREATMENT REQUIREMENTS

HEAT TREAT SCHEDULES PER TABLE X-X

TABLE X-X

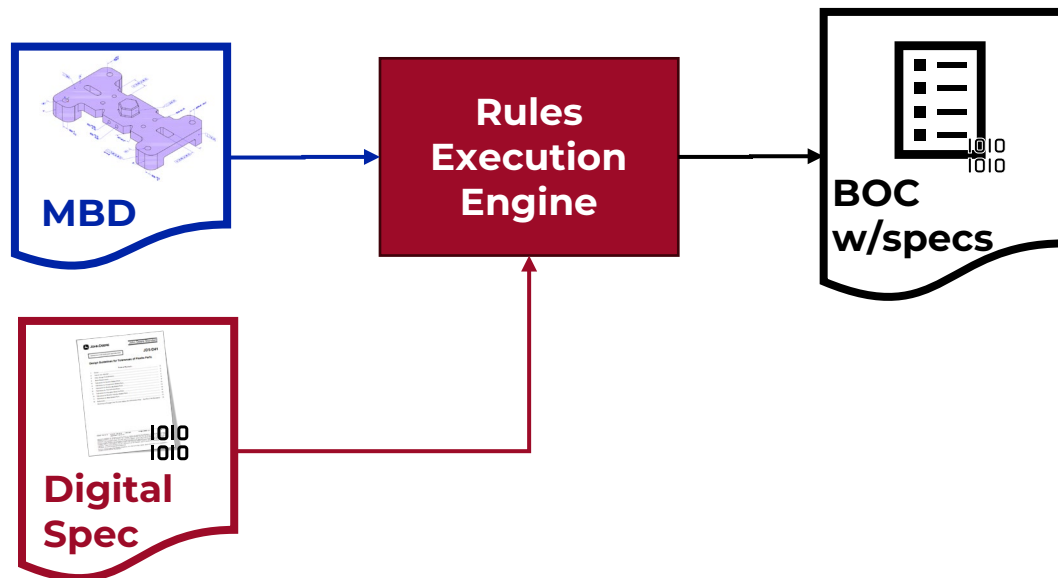
Temperature	xxxxx
Environment	xxxxx
Ramp Rate	xxxxx

The current state Specification architecture requires human interaction to apply precedence rules to resolve the apparent conflict between the “Face-of-Drawing” note and the referenced Specification.

Digital Standards & Specifications: Technical Overview

Workflow Summary

- **Inputs:** MBD + Digital Spec
- **Output:** BOC with appropriate characteristics



QIF-based

- **ISO standard**
- **Rich data model** (MBD, features, characteristics, expressions, rules)
- **Strong tool ecosystem**



QIF Rules Extension Language

```

<Rule>
  <Target?>...</Target?>
  <Parameters?>...</Parameters?> <!-- input parameters -->
  <CharacteristicTemplates?>...</CharacteristicTemplates?>
  <Actions?>...</Actions?> <!-- static action definitions -->
  <RuleBlock>...</RuleBlock> <!-- executable logic -->
</Rule>

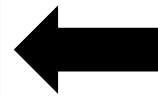
<!-- Logical unit -->
<RuleBlock UUID=...>
  <Variables?>...</Variables?>
  <Conditional|InvokeAction>...</Conditional|InvokeAction>
  <RuleBlock*>...</RuleBlock*>
</RuleBlock>

<!-- Conditional -->
<Conditional>
  <If>BooleanExpression + Then:RuleBlock</If>
  <!-- or -->
  <Choose>
    <When*>If (BooleanExpression + Then:RuleBlock)</When*>
    <Otherwise?>RuleBlock</Otherwise?>
  </Choose>
</Conditional>

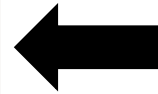
<!-- Actions -->
<Actions>
  <CreateCharacteristic|CreateDatum|CreateDatumReferenceFrame|EmitMessage>* ...
</Actions>

<InvokeAction>
  <InvokeCreateCharacteristic|Invoke...>
</InvokeAction>

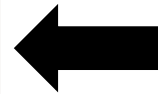
```



A Rule contains top-level rule data and a RuleBlock



A RuleBlock contains conditional statements or action invocations, plus an optional next RuleBlock in the chain



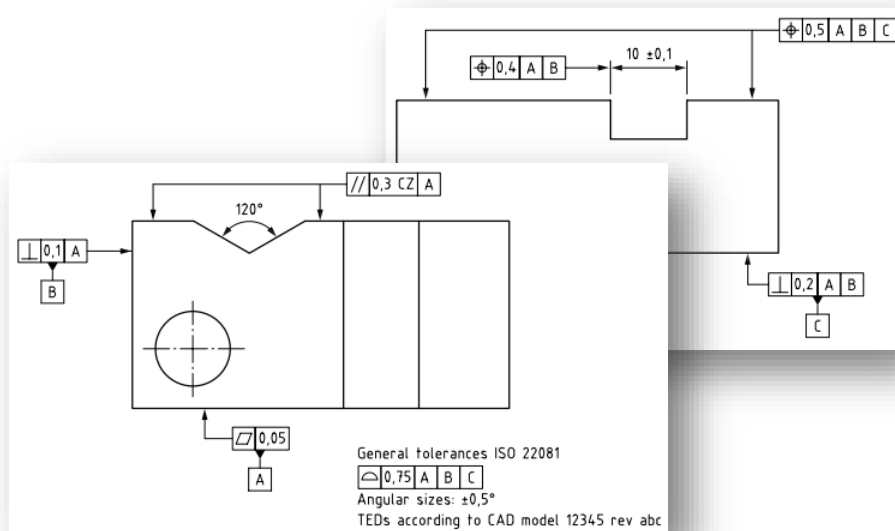
Actions and InvokeAction allow us to change the file, like adding characteristics or datums or emitting messages to the user

Use Case Example: ISO 22081:2021

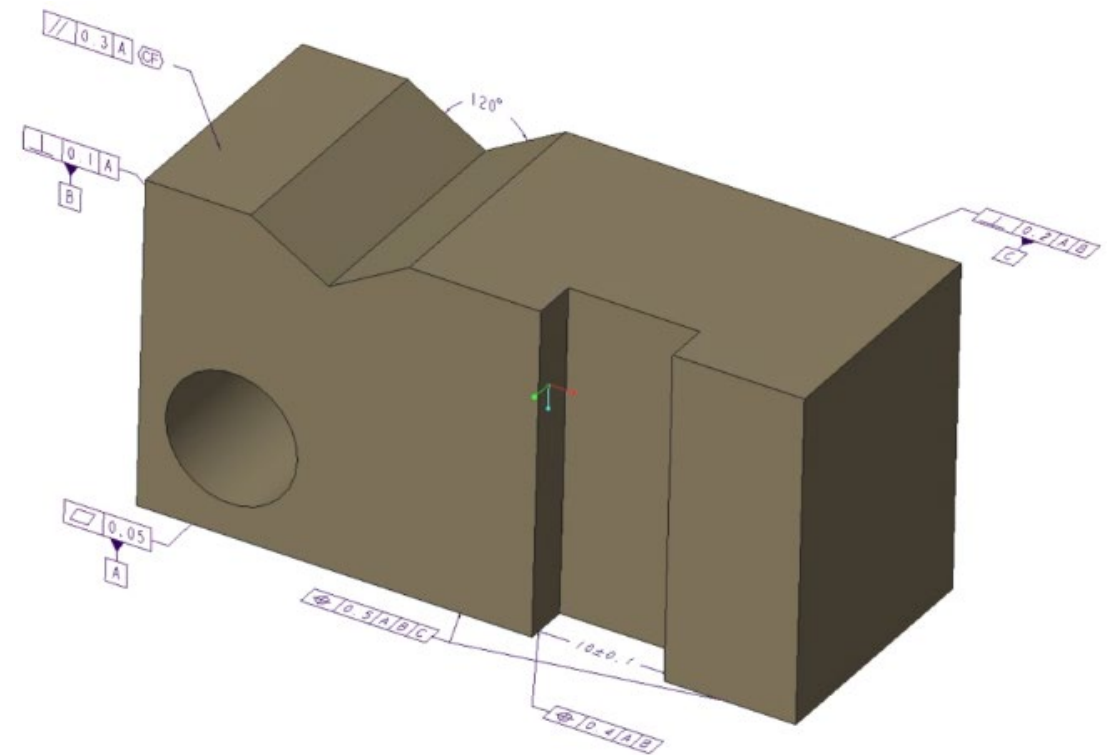
Geometrical product specifications (GPS) — Geometrical tolerancing — General geometrical specifications and general size specifications

ISO 22081:

Defines general **geometrical** and **size** tolerances to enable the concept of the **minimally annotated model**



[Image from ISO 22081:2021 figure 3](#)



General Tolerances ISO 22081
 Angular sizes: $\pm 0.5^\circ$
 All unspecified dimensions are basic

Use Case Example: ISO 22081:2021

Geometrical product specifications (GPS) — Geometrical tolerancing — General geometrical specifications and general size specifications

```
<rp:RuleExtension
  uuid="6d693626-7af4-4bbd-b572-7b6f0fe893af"
  specification="ISO 22081:2021"
  clause="Rule D">
```

Rule

```
<rp:Rule>
  <rp:Target>
    <rp:TargetEnum>FEATURE</rp:TargetEnum>
  </rp:Target>

  <rp:Actions>
    <rp:CreateCharacteristic
      id="create_iso22081_general_geometrical" />
    <rp:EmitMessage
      id="emit_iso22081_general_geometrical_message" />
  </rp:Actions>

  <rp:RuleBlock UUID="3aa1df71-06a5-4bc7-ac9f-2bb56fd68a73">...
</rp:Rule>
</rp:RuleExtension>
```

RuleBlock

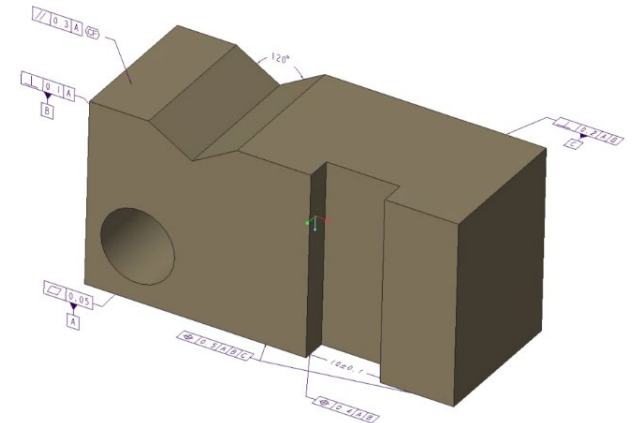
```
<rp:RuleBlock UUID="3aa1df71-06a5-4bc7-ac9f-2bb56fd68a73">
  <rp:Variables n="24">...
</rp:Variables>

  <rp:Conditional>...
</rp:Conditional>
</rp:RuleBlock>
```

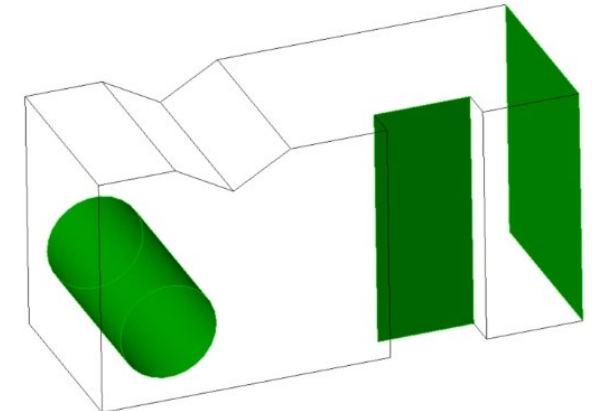
Conditional

```
<rp:Conditional>
  <rp:If>
    <!-- Activation note must exist in one of the note repositories -->
    <q:Or n="3">
      <q:GreaterThan>
        <rp:CollectionCount variableRef="iso22081_part_notes" />
        <q:ArithmeticConstant val="0" />
      </q:GreaterThan>
      <q:GreaterThan>
        <rp:CollectionCount variableRef="iso22081_notes" />
        <q:ArithmeticConstant val="0" />
      </q:GreaterThan>
      <q:GreaterThan>
        <rp:CollectionCount variableRef="iso22081_note_flags" />
        <q:ArithmeticConstant val="0" />
      </q:GreaterThan>
    </q:Or>

    <rp:Then UUID="83ff38e0-09f5-4b43-8586-b30d4fb3f95f">
```



General Tolerances ISO 22081
Angular sizes: $\pm 0.5^\circ$
All unspecified dimensions are basic



Thanks!

Q&A

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Future Work

- Digitize more real-world specs to identify gaps
- Enhance QIF Rules language
- Improve rules execution engine
- Develop rule authoring tools
- Drive industry adoption

See the implementation

- See the prototype implementation of the QIF Rules extension and the digital ISO 22081 implementation [here](#) →
- Upcoming paper presented at CIRP CAT 2026:

Campbell, D., Frank, E., & Braun, K. (2026).
Specifications-as-code: A system for creation of product characteristics from digital specifications.
 Procedia CIRP, 19th CIRP Conference on Computer-Aided Tolerancing (CAT 2026).

