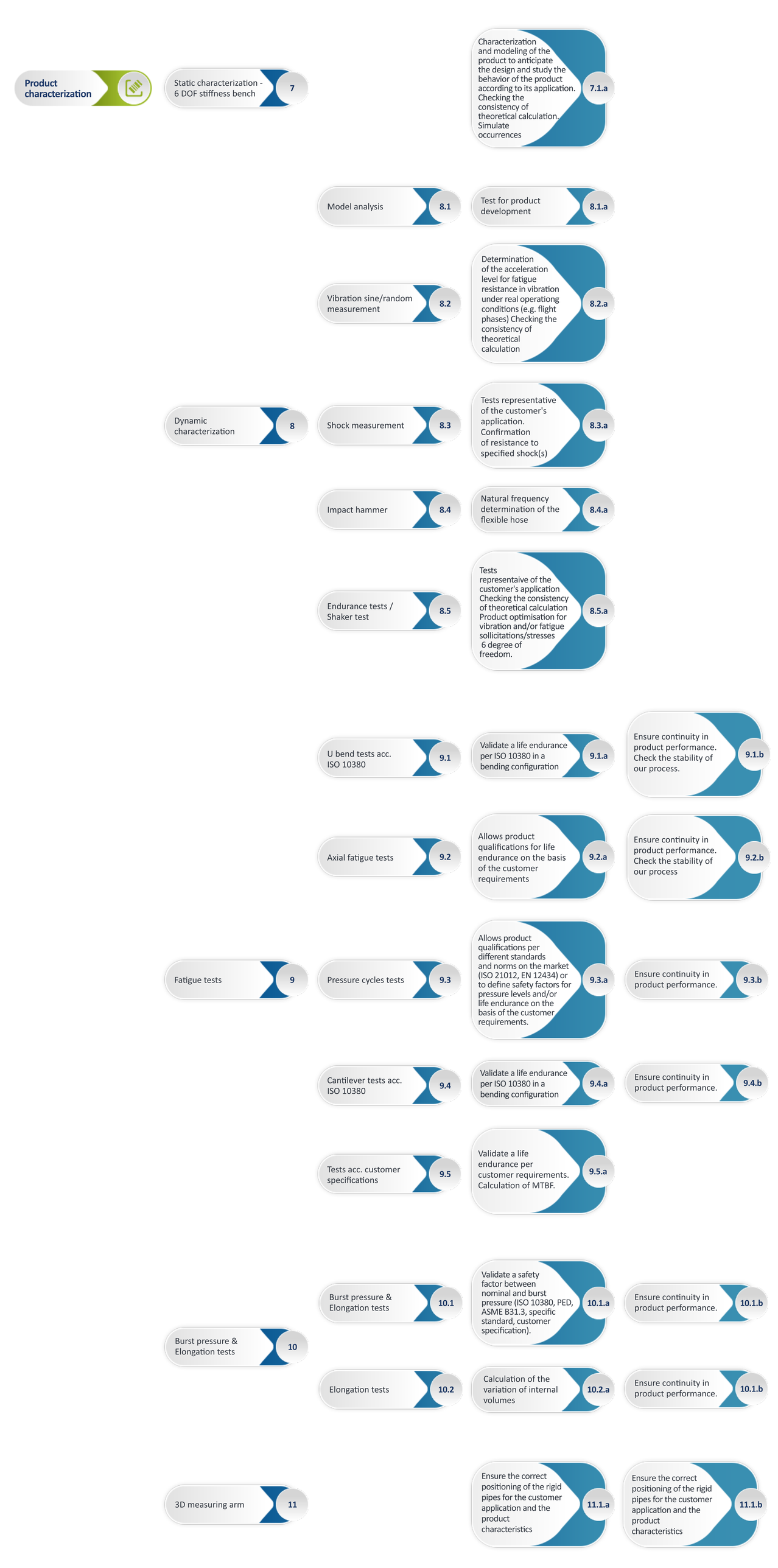
PROPERTY	MACHINERY	APPLICABILITY	DEVELOPMENT	IN-PROCESS
Material characterization	Digital high accuracy microscopy 1	Dimensional controls 1.1	Ensure the correct positioning of the pipes for the customer application and the product characteristics 1.1.a	Verification of corrugation geometry 1.1.b
		Roughness controls 1.2	Reduce the risk of localized corrosion and/or reduce adherence to reduce pressure drop. Have a guaranteed level of tightness. 1.2.a	
		Surface depth controls 1.3	Ensure the expected life endurance on the basis of the customer requirements 1.3.a	
		Metallography 1.4	Ensure mechanical characteristics and/or corrosion resistance. Check the metallurgical continuity between the core material and the weld material 1.4.a	
	Industrial computed tomography (CT) 2	3D reconstruction on surface 2.1	Ensure the product characteristics 2.1.a	Product reliability Surface defect 2.1.b
		3D metrology 2.2	Ensure the dimensionnal characteristics 2.2.a	
		Welding defect analysis 2.3	Validate products acc to standards for fusion welding (NF EN ISO 5817, NF EN ISO 24394, DIN 29595...) 2.3.a	Verification of thickness variations / reduction of area 2.3.b
	Scanning Electron Microscope & X-ray microanalysis 3	Fractographic analysis 3.1		Analyze the failure mode to determine the root cause of the rupture 3.1.b
		Corrosion mechanism analysis 3.2		Analyze the corrosion mechanism to determine the type of corrosion and which fluid could be responsible of the rupture 3.2.b
		Surface analysis 3.3		Analyse the possible presence of micro defects on the surface 3.3.b
		Chemical analysis 3.4		Check the chemical composition of the material (and contamination) 3.4.b
		Material / Welding defects analysis 3.5		Analyze the defects to determine the root cause of the rupture 3.5.b
	X-ray fluorescence analysis 4			Check the chemical composition of the material 4.1.b
	Hardness tests & Tensile testing machine 5	Vickers Hardness measurement 5.1		Check the mechanical characteristic of the material 5.1.b
		Mechanical properties measurement 5.2	Ensure that the product will withstand the mechanical stresses 5.2.a	Check the mechanical characteristic of the material 5.2.b
				Check the Charpy V-notch characteristic of the material 5.2.b
	Delta ferrite content measurement 6		Ensure that the delta ferrite content is not high (reduces corrosion resistance) or not too low (loss in strength) 6.1.a	Ensure that the delta ferrite content is not high (reduces corrosion resistance) or not too low (loss in strength) 6.1.b

Product calculation / sizing

- FEA Simulations **18**
  - Flow simulations **18.1**
    - Definition of maximal allowable speed for any gas. Confirm customer estimation's or recommandation for hose diameter optimization **18.1.a**
  - Hose forming simulations **18.2**
    - Design of new corrugation shape validated for target pressure 3D model database for CX hose range. Digital proof of concept **18.2.a**
  - Braided hose behavior simulations **18.3**
    - Simulation of pressure cycles. Life endurance estimation. **18.3.a**
  - Pressure drop calculations **18.4**
    - Characterization of generic pressure drop curves. Calculation of effective pressure drop in customer configuration **18.4.a**
  - 3D configurations **18.5**
    - Simulation of hose behavior with reaction forces and cycle life **18.5.a**
- According to CoreDux proprietary softwares **19**
  - Convolution shape **19.1**
    - Calculation of life endurance according to the deflections **19.1.a**
  - Hose assembly innovations **19.2**
    - Determination of the optimum assembly according to customer's application. Technical survey by cross-fertilisation **19.2.a**
  - Optimisation of the braiding parameters **19.3**
    - Rapid developmen of new products **19.3.a**
  - Theoretical calculation of the burst pressure **19.4**
    - Rapid developmen of new products **19.4.a**
- According to pressure vessel code **20**
  - Normative proof of concept. Confirm customer estimation's or recommandation for hose diameter optimization **20.1.a**


Product characterization
Static characterization - 6 DOF stiffness bench
7
Characterization and modeling of the product to anticipate the design and study the behavior of the product according to its application. Checking the consistency of theoretical calculation. Simulate occurrences
7.1.a
Model analysis
8.1
Test for product development
8.1.a
Vibration sine/random measurement
8.2
Determination of the acceleration level for fatigue resistance in vibration under real operationg conditions (e.g. flight phases) Checking the consistency of theoretical calculation
8.2.a
Dynamic characterization
8
Shock measurement
8.3
Tests representative of the customer's application. Confirmation of resistance to specified shock(s)
8.3.a
Impact hammer
8.4
Natural frequency determination of the flexible hose
8.4.a
Endurance tests / Shaker test
8.5
Tests representaive of the customer's application Checking the consistency of theoretical calculation Product optimisation for vibration and/or fatigue sollicitations/stresses 6 degree of freedom.
8.5.a
U bend tests acc. ISO 10380
9.1
Validate a life endurance per ISO 10380 in a bending configuration
9.1.a
Ensure continuity in product performance. Check the stability of our process.
9.1.b
Axial fatigue tests
9.2
Allows product qualifications for life endurance on the basis of the customer requirements
9.2.a
Ensure continuity in product performance. Check the stability of our process
9.2.b
Fatigue tests
9
Pressure cycles tests
9.3
Allows product qualifications per different standards and norms on the market (ISO 21012, EN 12434) or to define safety factors for pressure levels and/or life endurance on the basis of the customer requirements.
9.3.a
Ensure continuity in product performance.
9.3.b
Cantilever tests acc. ISO 10380
9.4
Validate a life endurance per ISO 10380 in a bending configuration
9.4.a
Ensure continuity in product performance.
9.4.b
Tests acc. customer specifications
9.5
Validate a life endurance per customer requirements. Calculation of MTBF.
9.5.a
Burst pressure & Elongation tests
10
Burst pressure & Elongation tests
10.1
Validate a safety factor between nominal and burst pressure (ISO 10380, PED, ASME B31.3, specific standard, customer specification).
10.1.a
Ensure continuity in product performance.
10.1.b
Elongation tests
10.2
Calculation of the variation of internal volumes
10.2.a
Ensure continuity in product performance.
10.1.b
3D measuring arm
11
Ensure the correct positioning of the rigid pipes for the customer application and the product characteristics
11.1.a
Ensure the correct positioning of the rigid pipes for the customer application and the product characteristics
11.1.b

Product cleanliness / leak reliability

Leak testing **16**

- He leak testing (vacuum overpressure, integral) **16.1**
  - Measure a leak level **16.1.b**
- Pressure decay testing **16.2**
  - Identify the presence of a potential leak **16.2.b**
- Air bubble test **16.3**
  - Identify a potential leak area **16.3.b**

Pressure testing **17**

- Pressure proof test (gas & water) **17.1**
  - Ensure the mechnical strength of a flexible pipe **17.1.b**

Product cleanliness

- Optical particle analysis **12**
  - UVA inspection **12.1**
    - Avoid system pollution **12.1.a**
- Rotary evaporator **13**
  - Cleanliness level measurement for oxygen application **13.1.a**
- Chemical cleanliness **14**
  - TOC analyses (gas & water) **14.1**
  - RGA analyses **14.2**
  - XPS measurement **14.3**
- Particle cleanliness **15**
  - APC **15.1**
  - LPC **15.2**