Verification / Qualification
Certification and its significance
Release processes
Configuration Management
Change Management
In-service Issues

Boeing India University Relations
Industry Ready Engineer
Curriculum Enhancement Program

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Content

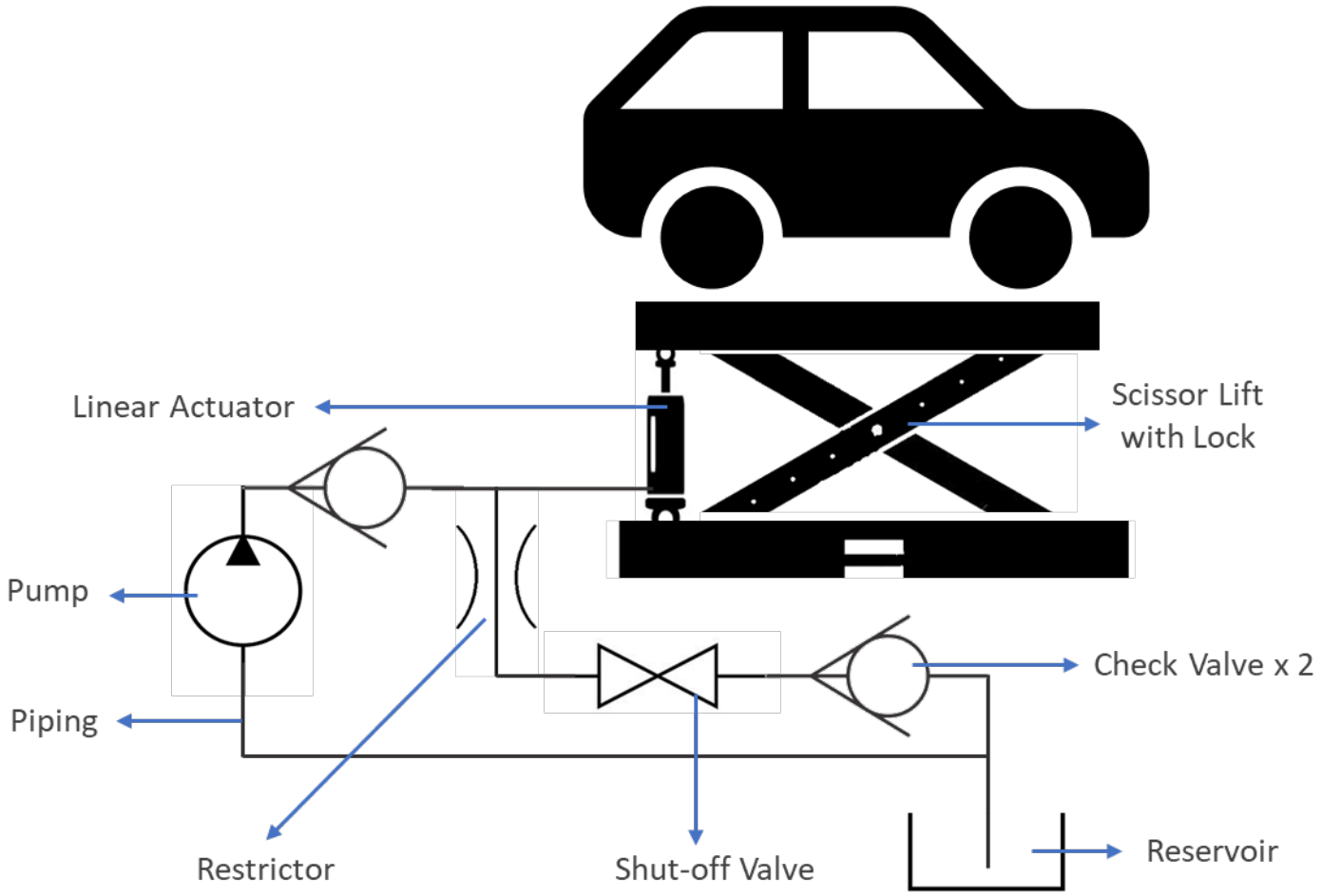
Verification, Certification & Configuration Management (2 hours)

Verification of Design

-Qual. Plan
-Qual. Procedure
-Analysis & Significance
-Qual. Report – Test, Similarity, Analysis, Inspection

- **Certification and its significance**
- **Release processes**
- **Configuration Management**
- **Change Management**
- **In-service Issues**

Scissor lift System Architecture Overview



Design & Develop

1. Scissor Lift with Lock
2. Restrictor
3. Linear Actuator
4. Shut-off Valve
5. Check Valve

COTS Selection

1. Pump
2. Piping
3. Reservoir
4. Hydraulic Fluid

Integrate all components per workshop lift schematic & layout

Verification

Verification is process of ***evaluation*** of whether or not a product, service, or system **complies** with a **regulation, requirement, specification**, or imposed condition.

- The **evaluation** of an implementation of requirements to determine that the **requirements** have been met (did we build the system/function / LRU right).
- **Definition** of the **process** and **criteria** to be applied when showing how the implementation satisfies its requirements.
- Verification process **ensures** that the system implementation satisfies the validated requirements.

Verification process objectives:

The verification process confirms that the **intended functions** have been correctly implemented Confirms that the **requirements have been satisfied** (have we built the system right)

Ensures that the **safety analysis** remains valid for the system as implemented.

Verification process model

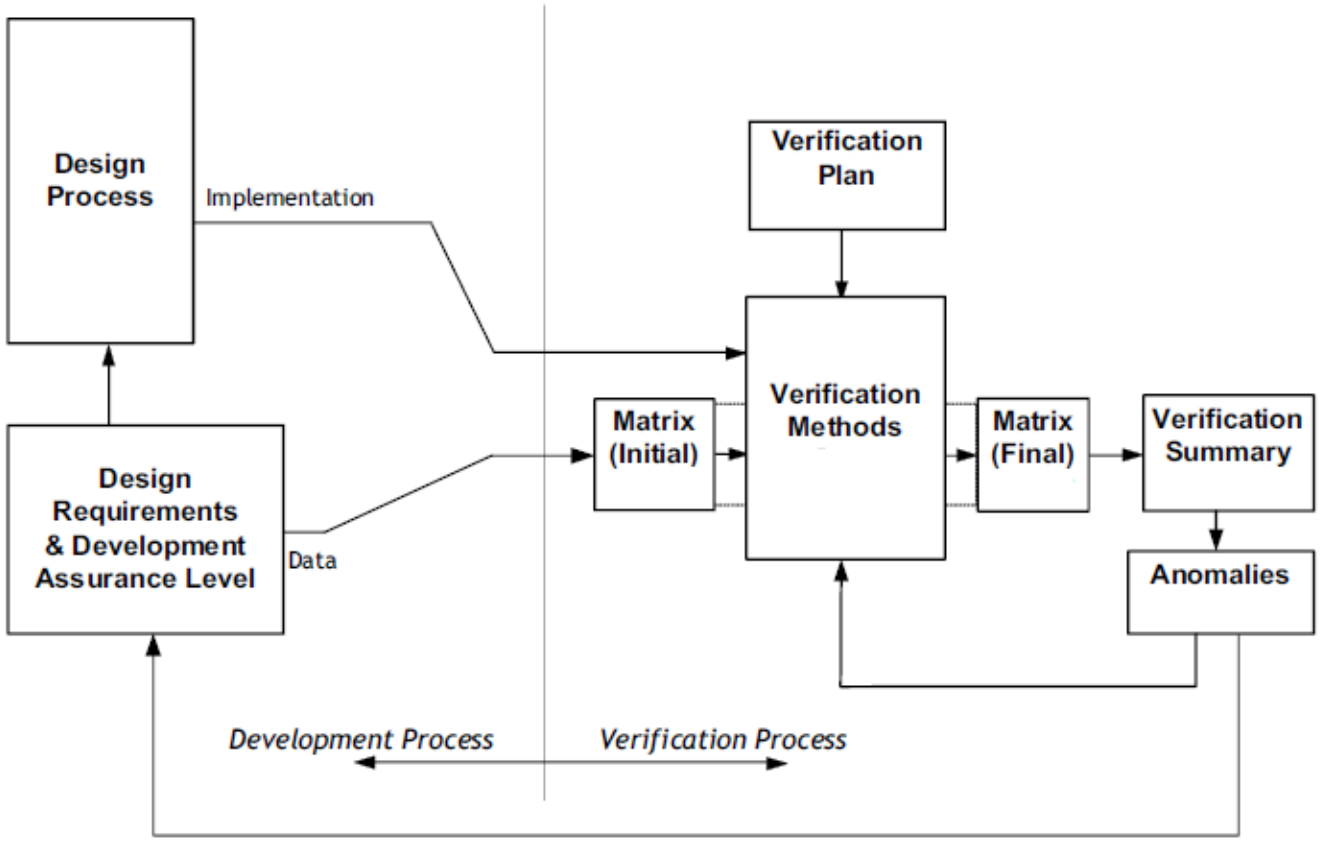


Figure-1: Verification process model

Planning: Includes planning for the **resources** required, the **sequence of activities**, the **data to be produced**, collation of required information, selection of specific activities and **assessment criteria**, and generation of verification specific hardware or software.

Methods: Includes the activity in which the verification methods are employed.

Data: Includes evidence of the results developed in the process.

Verification process model

Verification is a process which due to the iterative nature of the development process may appear repeatedly during design process.

1. Verification planning:

The purpose of this phase is to define the ***process and criteria to be applied*** when showing how the implementation satisfies its requirements. The following activities should be performed during the planning phase:

1 Identification of the **roles and responsibilities** associated with conducting the verification activities.

2 Identification of the ***system or item configuration***, including the definition of any special test equipment facilities and any special hardware or software features to be verified.

3. Definition of the ***specific verification method*** to be employed to show compliance with each requirement

4. Definition of the ***criteria to be used to assess the evidence*** resulting from each verification method applied.

5. Identification of ***system verification credit*** taken from hardware or software verification activities.

6. Identification of key verification activities and sequence of any dependent activities.

7. Identification of verification data.

Verification methods

The purpose of these activities is to verify that the implementation satisfies its requirements including the intended operating environment. Four basic methods may be employed in the verification of the system or item.

1. Inspection or review, (**visual examinations** of the process documents, drawings, hardware, or software to verify that requirements have been satisfied)
2. Analysis, (analysis provides **evidence of a compliance** by performing a detailed examination (e.g. functionality, performance, safety) of a system or item)

   2.1 Modeling (Modeling may be used for **system parameter evaluation** to provide early system information or other purposes)

   2.2 Coverage analysis (performed to determine the **degree to which the requirements are addressed** throughout the development and validation activities)

(**Example**: Performance analysis of the scissor lift system can be found in Page-27 and Kinematic analysis of the of the scissor lift system can be found in page 28 & 29)

3. Test or demonstration, (To ***demonstrate that the system or item implementation performs its intended functions*** & ***provide confidence*** that the implemented system ***does not perform unintended functions)***
4. Similarity / Service experience (design and installation appraisals and evidence of satisfactory service experience on other systems that are similar in their relevant attributes)

Verification data

The purpose of verification data is to provide ***evidence that the verification process was conducted***.
This evidence may be required for compliance substantiation and to support certification data requirements.

A reasonable approach is to maintain a ***verification matrix*** during development and to produce a ***verification summary report***.

3.1 Verification Plan
The verification plan establishes the ***strategies*** to show how the system implementation satisfy their requirements.
A typical verification plan might include: (slide 6)

3.2 Verification Procedures and Results
data describing the verification procedures together with the results achieved provides the evidence necessary to establish the ***appropriateness of the verification effort***.

3.3 Verification matrix
A verification matrix or an equivalent tracking document should be produced to track the status of the verification process.

3.4 Verification summary
The verification summary provides visibility for the evidence used to show that the system or item implementation satisfies its requirements.

Qualification

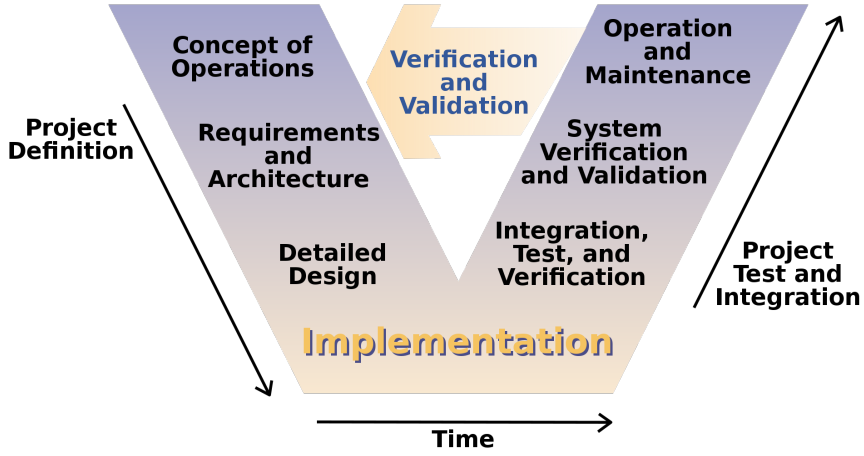
- Qualification is process of verifying whether a product meets or exceeds the reliability and quality requirements of its intended application.
- Qualification plays an important role in the process of product development.
- It can be classified by its specific purpose at different stages of the product development process.

Qualification shall normally be conducted at the component level; however, it is acceptable for a component contained in a unique assembly to be qualified on the basis of qualification of the higher assembly.

Qualification of the higher assembly shall result in an acceptable qualification of the component.

Qualification is mandatory for a component **that** has been assessed as a critical item (or single failure point) by Failure Modes and Effects Analysis (FMEA)

And highly desirable for a component if failure of the component would result in sufficient operation degradation to cause the system, subsystem, or assembly to perform at a point lower than the minimum acceptance level.



Methods of Qualification:

- Qualification by ***Testing***
- Qualification by ***Similarity***
- Qualification by ***Usage*** and ***Analysis***
- Qualification by ***Demonstration***
- Qualification by ***inspection***

Qualification in product development process

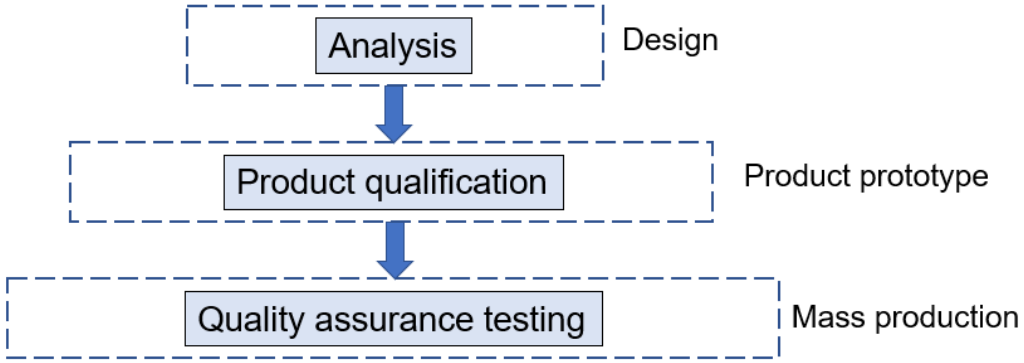


Figure-2: Qualification activity in different stages of product development

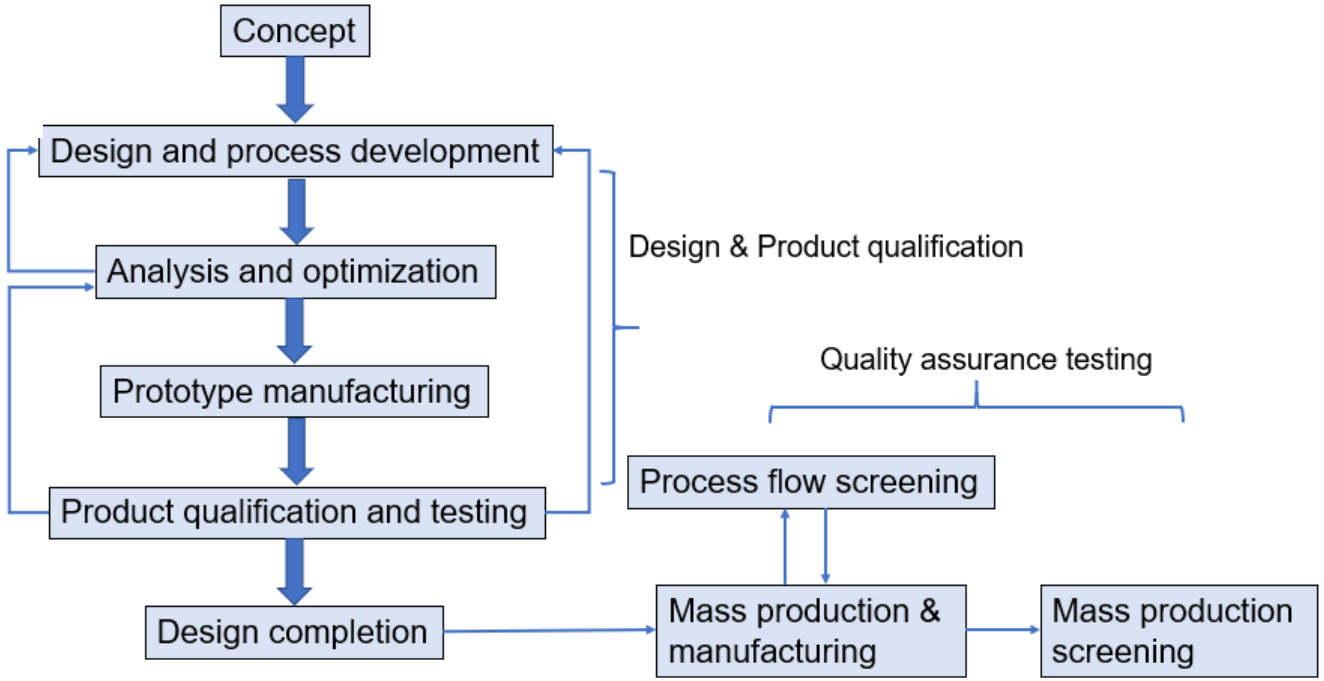


Figure-3: Qualification and quality assurance testing within the product design and manufacturing process flow including iterative feedback process

Qualification in product development process

Qualification occurs in different stages of the product development process, as shown in **Figure 2**. Qualification activities in different stages have different purposes.

1. ***Analysis*** is to evaluate the functional and reliability performance of the product design without any physical testing on the product.

2. ***Product qualification*** is to evaluate the product based on the physical testing on the manufactured prototype.
   The purpose is to verify whether the product has met or exceeded its intended quality and reliability requirements.

3. After analysis and product qualification, the products are mass produced. During and after the manufacturing process, the products can be inspected and tested to evaluate their quality and defected parts can be screened out. This process can be considered as a third stage in the overall qualification process, and it is more commonly referred to as ***quality assurance testing***.

At various intersections of the process, maturity levels can be assigned to indicate progress and specific readiness for the next phase. The design and product qualification process may include feedback iterations shown in **Figure 3**.

The objectives of qualification testing are to

(a) evaluate the ***quality of a product*** to see if it meets the design requirements,
(b) develop information on the ***integrity of a product*** and its structure,
(c) estimate the expected ***service life*** and ***reliability*** and
(d) evaluate the ***effectiveness of materials***, ***processes***, and ***designs***.

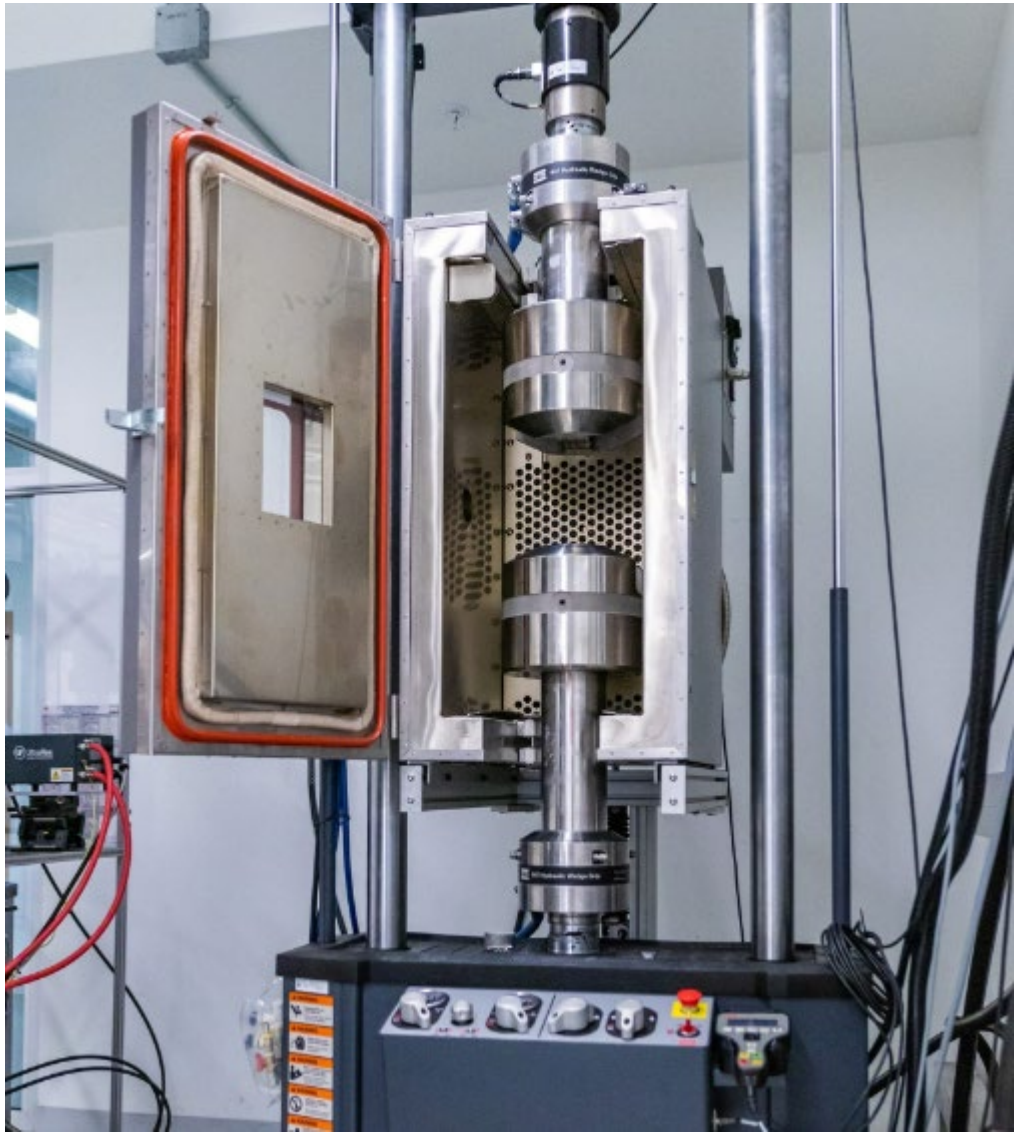
Qualification tests estimate ***expected life*** and ***design integrity*** of a product. Most tests are not conducted under the normal application conditions, but at accelerated levels of stresses to accelerate potential failure mechanisms at associated sites in a product.

Product Qualification & Quality assurance testing

Product qualification is the evaluation of products after prototype manufacturing. It is intended to qualify a product before its mass production. The qualification includes the verification of their function and performance, the validation in the system application (if applicable) and the qualification for processability and reliability. After the qualification, products' specifications that do not meet the design and customer requirements should be reported to the design team for correction action. Parameters in qualification tests, failure modes and failure mechanisms of products during qualification tests will be provided to the design team as feedback on how to improve the design or the manufacturing process.

The ***qualification tests*** that take place during mass production and before the products are shipped to the customer are more properly considered to be ***quality assurance testing*** that ensure that the products are manufactured according to the design within allowable tolerances.
Furthermore, accelerated stresses are applied to the products to accelerate early failures that are caused by manufacturing defects. These ***qualification tests*** ensure the quality of products that will be used in field applications. Manufacturing defects are screened out of the product shipping list.

Product Qualification & Quality assurance testing



Methodology of product qualification

The methodology includes collecting product configuration and material information, collecting product life cycle profile, strength limit and margins, Failure Mode, Mechanisms and Effects Analysis (FMMEA), defining qualification requirements, **Qualification Test Planning**, **Testing**, **Failure Analysis** and verification and quality and reliability assessment. A flowchart is shown in Figure 5.

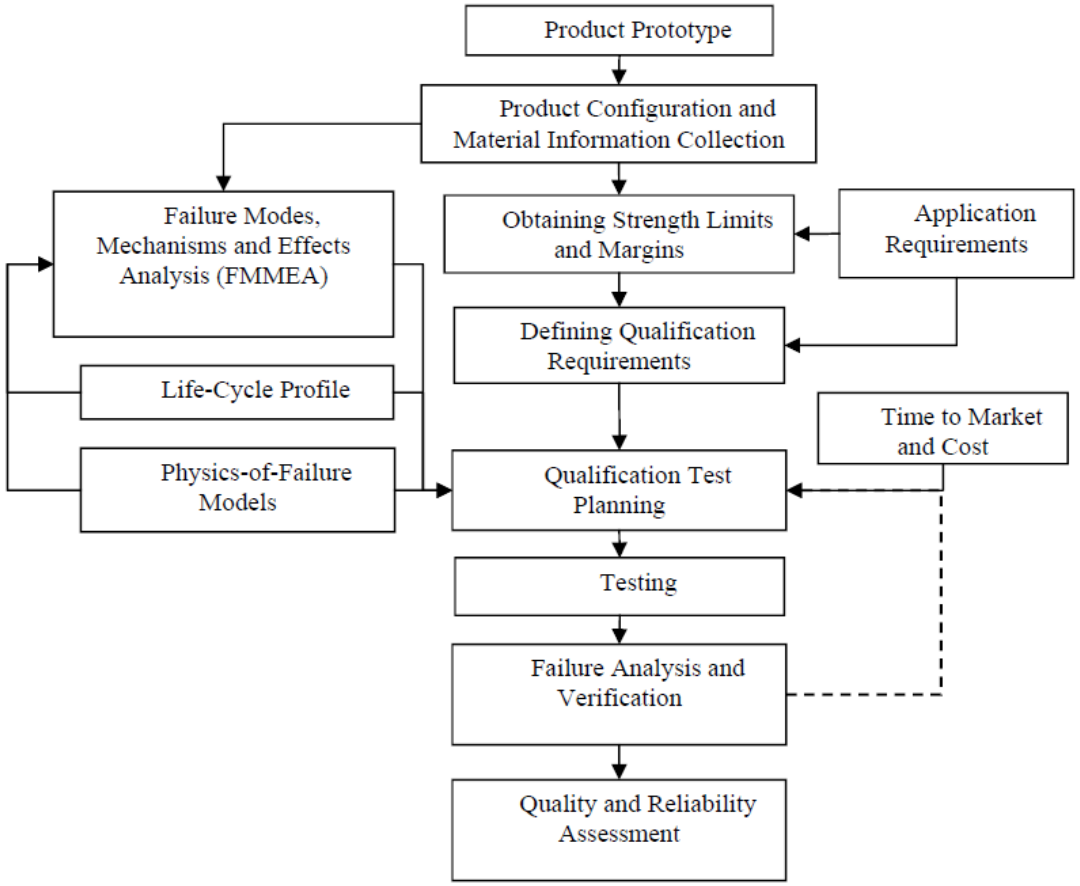
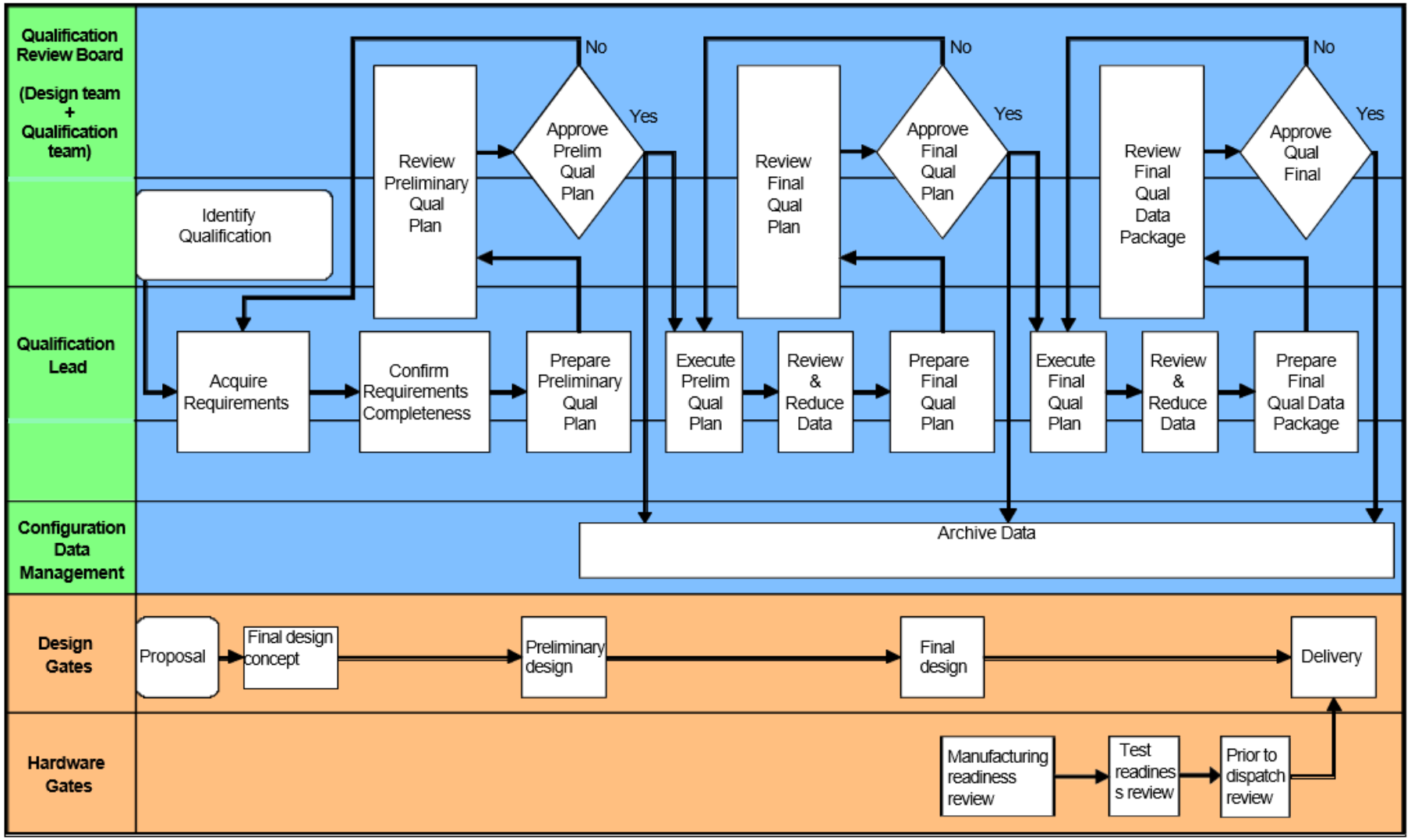


Figure 5 : Flowchart of methodology of product qualification

Qualification Process

Stage	Input for Qualification Test	Qualification Test Procedure (QTP)	Qualification Test	Test Documentation
Responsibility	Engineering team of the equipment manufacturer provides the required inputs. However if supplier owns a system, supplier can have their own input in concurrence with Equipment manufactures inputs.	QTP is developed by the test lab in concurrence with Equipment manufacturer. In case testing is done in-house, Equipment manufacturer creates the QTP.	Test lab & Engineering team have the responsibility to ensure success	Test lab prepares the documentation. Equipment manufacturer Engineering team reviews & apporves the content
Importance	This stage ensure all inputs are gathered while deciding the test requirement. Impact on cost & schedule of project due to any rework at this stage may be very minimum.	This stage ensures all the detail procedure of testing are captured & documented as a baseline. Impact on cost & schedule of project due to any rework at this stage may be minimum to moderate	During this stage, qualification tests are executed in accordance with QTP and test data are recorded. Impact on cost & schedule of project due to any rework at this stage may be moderate to high	During this stage the test data & inspection data recorded are analysed to conclude the result. Then failure results are taken for further analysis to find root cause. Successfull pass results are documented in accordance with QTP. Impact on cost & schedule of project due to any rework at this stage may be very high.
Product Lifecycle stage	This stage is started before Preliminery design review and concluded in finalized design review	This stage starts after finalized design review	This stage starts after TRR (Test readiness review)	This stage starts along with the beginning of test and concludes after all test data is available
Expected outcome	- List of tests to be conducted. - How many optimal LRUs to be built. -Test plan along with sequence of test. -And other logistics such as test facility/ lab selection.	Detail test procedure covering requirements, test steps, test condition, instrumentation and expected results (pass/fail criteria)	Test data, Inspection data, Test photos, Test deviations & approvals	Test report, Problem reporting along with RCCA

Qualification Overview

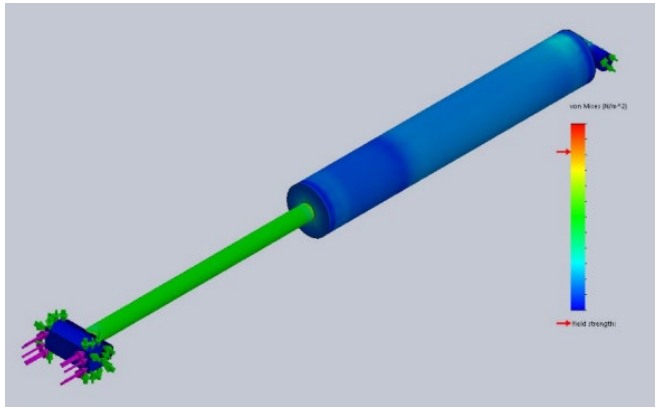


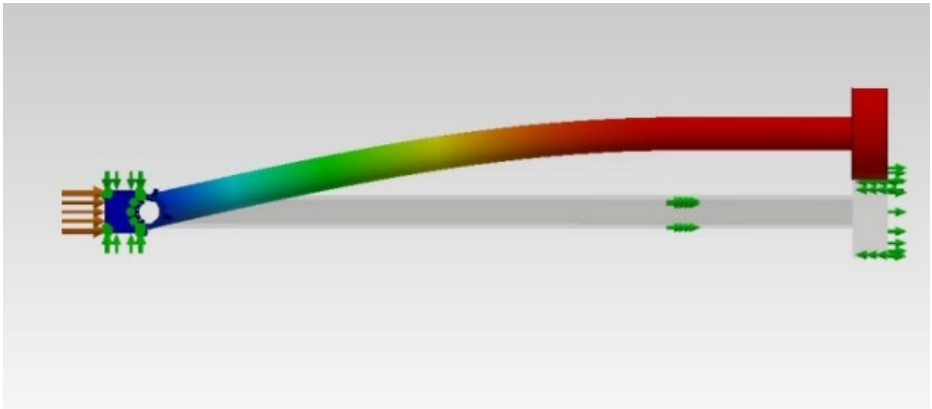
The basic ***Qualification Process*** and ***Independent Review Model*** is shown in Figure 6
(Curtesy: https://aerospace.org/sites/default/files/maiw/TOR-2010(8591)-20.pdf)

Analysis

1. Analysis is a methodology for assessing and improving the reliability of products through the use of validated failure models and simulation tools.
2. It is also an ***important step in developing effective physical tests*** to verify product reliability.
3. Analysis is the first stage of the overall qualification process. It is the application of PoF based reliability assessment to determine if a proposed product can survive its anticipated life cycle.
4. Analysis assesses whether a part or system can meet its reliability goals under anticipated life cycle profiles based on its materials, geometry, and operating characteristics.

The technique involves the application of simulation software to model physical hardware to determine the probability of the system's meeting desired Functional goals.





Analysis

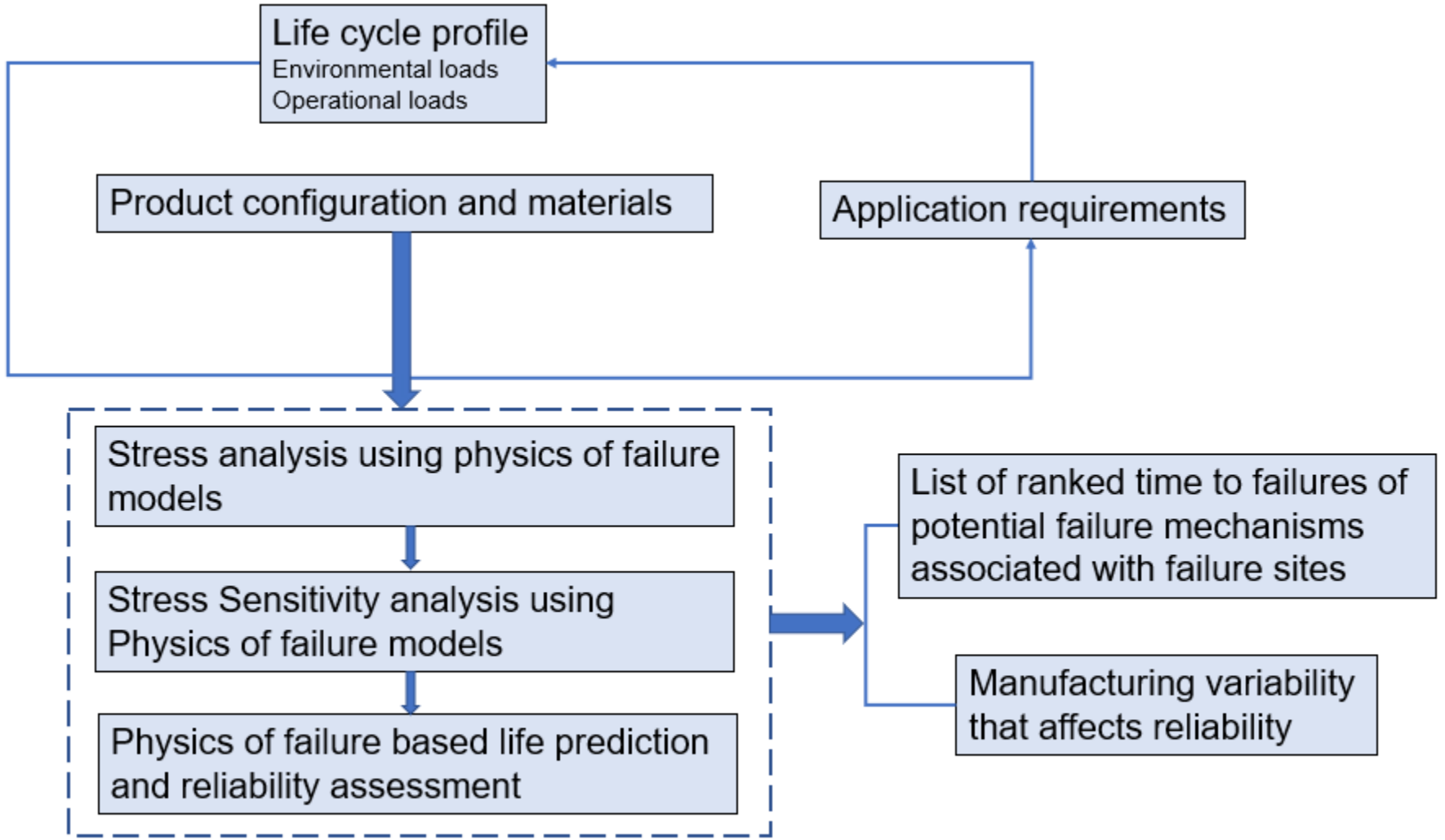


Figure-4: Flowchart of Analysis

Qualification plan

Qualification tests are accomplished on system/LRU that are totally representative of future production system/LRU. These tests shall establish, as far as practical under laboratory conditions, that the system/LRU will comply with the design requirements of the SCD (Supplier controlled document), and will perform its intended function as defined in the SCD and will meet the operational safety requirements.

Qualification tests may be performed at the supplier's place of manufacture or by a testing laboratory that has been approved by manufacturer / authorized agencies, prior to the actual test. The format and content of all test data shall be agreed upon prior to testing.

Qualification test plan

Qualification test planning is a process of transforming the detailed verification requirements captured in the program specifications, and mapped to a test method, into a comprehensive series of testing tasks that collectively and least expensively expose the relationship between item capabilities and the development requirements for all of the items in the system.

Qualification test plan shall have a direct correlation between its content and the requirements of the SCD to facilitate the review and approval process. The qualification plan shall include a ***test schedule*** compatible with the requirements of the SCD and ***purchase order schedule***. To the extent possible, the plan should provide for completion of the qualification test report prior to delivery of the first production article.

Qualification Test Procedure & Qualification Report

Based on the qualification test requirements, the individual tests are further elaborated to include step by step test procedure to form a qualification test procedure (QTP). Hence each test listed in qualification test requirement will have separate QTP.

The supplier shall submit a qualification test procedure for equipment manufacturers approval prior to start of qualification testing. There shall be a direct correlation between the content of the qualification test procedure and the requirements of the SCD to facilitate the review and approval process. Reference to the applicable SCD paragraph number in the qualification test procedure is recommended. The qualification test procedure shall describe, step by step, the tests that are used and the accept-reject criteria for each delineated test.

Qualification Report

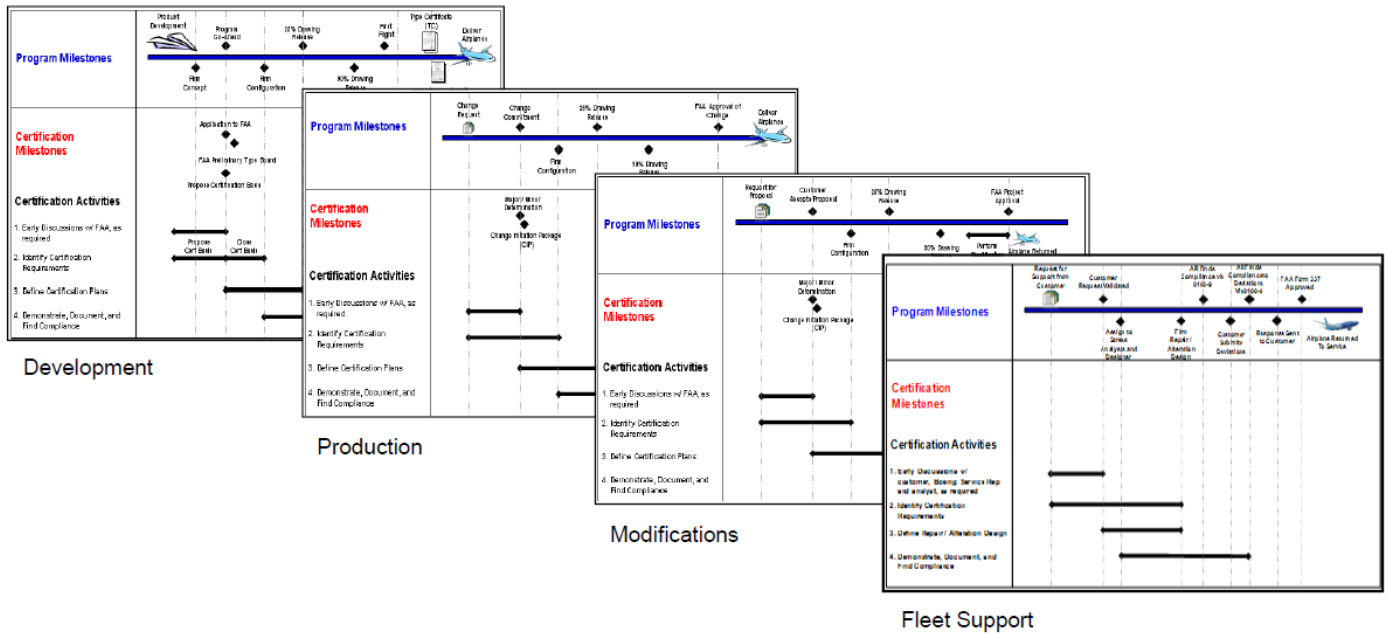
Correlation must exist between the Qualification Report, the Qualification Plan, and the Qualification Test procedure. To facilitate the review and approval process, Qualification Reports shall be prepared in such a manner that there is a direct correlation between the various portions of the data presented and the corresponding requirements in the SCD which the data are intended to satisfy. Reference to the applicable SCD paragraph number in the Qualification Report is recommended. Where practical, use the same paragraph numbering as used in the SCD.

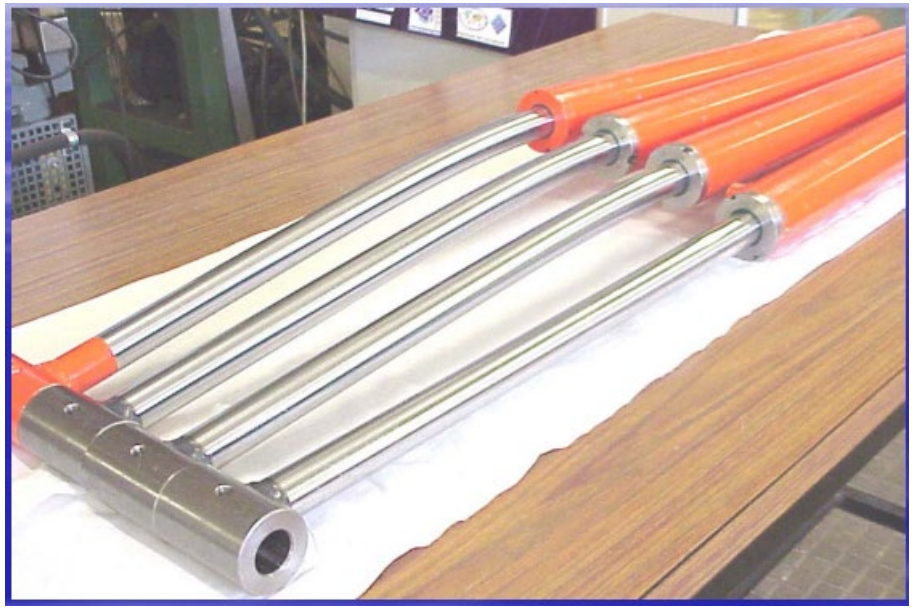
Certification and its significance

The objective of the certification process is to ***substantiate that the system and its LRU comply with applicable regulations***. In most situations the system certification is accomplished through compliance with a series of certification plans (including references to plans for equipment qualification). Planning and coordination are vital to:

- establish effective communications between the applicant and the certification authority,
- reach agreement on the intended means of showing that the system, its LRU / items meet specific regulatory requirements, and industry standards.

When does Certification begin?





Product used in the system without certification

When does Certification End?

Certification ends when all demonstrations of compliance by manufacturer of system and all findings of compliance by the certifying agency are complete

Certification considerations

Product release process

Product release management refers to the process of releasing system/LRU to the public and the steps involved from start to finish — planning, designing, scheduling, testing, deploying, and controlling.

A clear vision: As the product launch can't happen without the help of internal departments' support, make sure of goal and understand the aim of and need for the product.

A strategy: How to bring the product to market? A strategy defines how to go from A to B. This is a customer-focused plan with tasks and timelines built around delivering value to the end-user. It'll help to focused and moving in the same direction.

A communication plan: Regular catch-ups, team meetings, scrums, stand-ups, stakeholder and board meetings — they all help to keep everyone aware of the current state of play and how the product launch plan is progressing.

A product launch checklist: A list of final pre-launch activities to ensure the product launch is a success.

A system to measure success: To understand how product is performing, and subsequently improve it, there is need of a system to measure the success. Through it, is possible to monitor revenue, adoption, engagement, and satisfaction, and look at customer and market feedback to enhance offering.

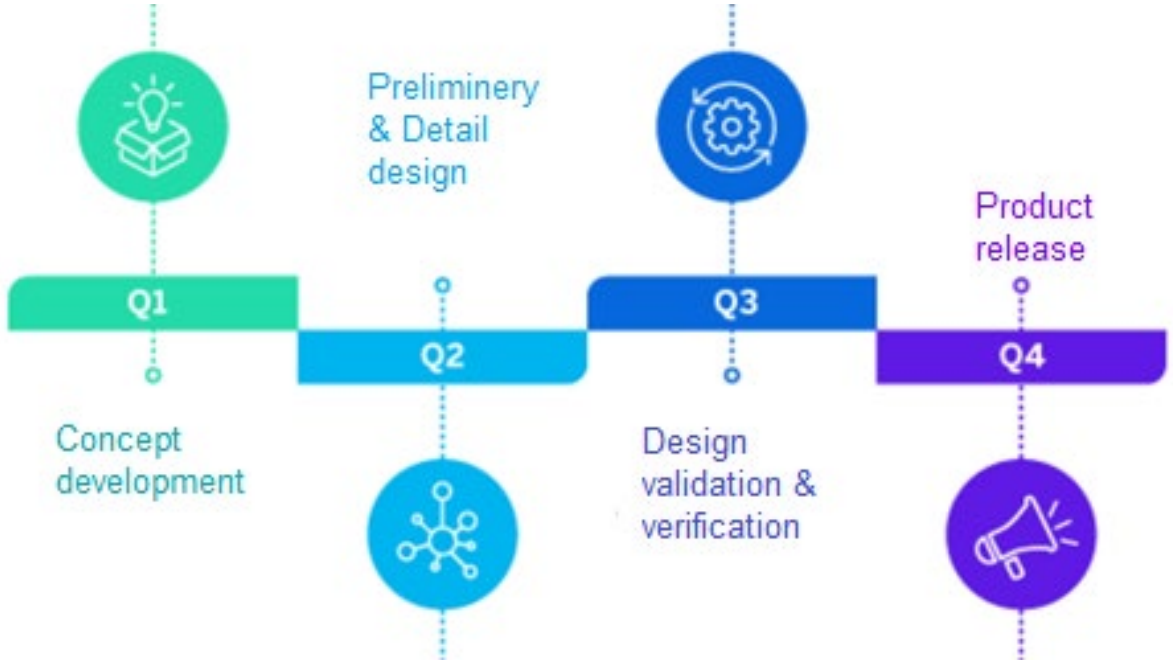


Figure-7: Product development and release

Configuration management

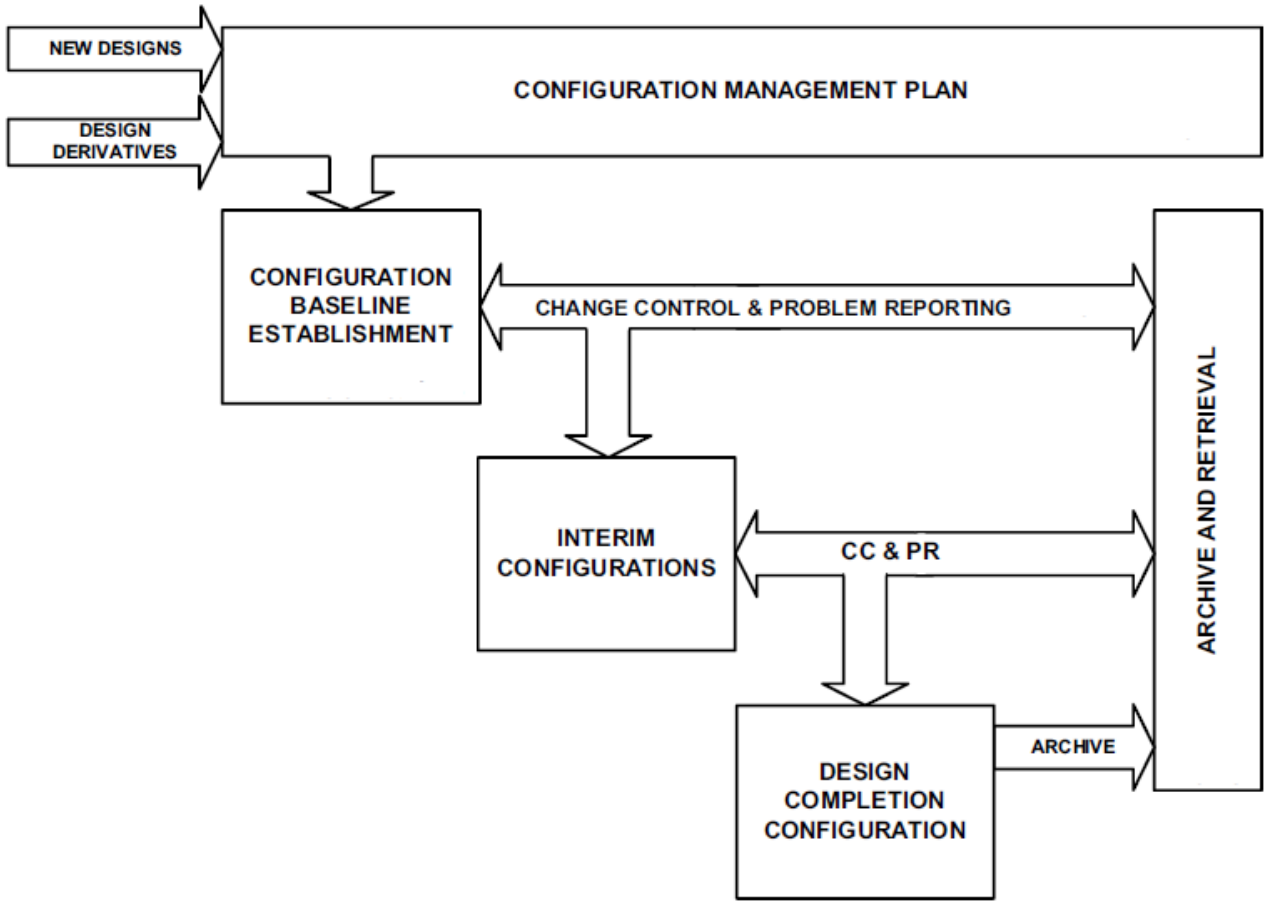


Figure-8: Configuration management

Configuration Management Process Activities:

The configuration management process shown in Figure-8 includes

a. Configuration management plan,
b. Configuration identification,
c. Baseline establishment,
d. ***Change control and problem reporting,***
e. Archiving and retrieval activities.

Continuity of these activities significantly enhances their effectiveness and the credibility of the overall configuration
management process. For certification purposes, evidence of a continuous configuration management process may
include, but is not limited to, historical records or successive reports from these activities.

Change management

The objective of change management and problem reporting is to record changes or issues identified during review, testing or service and their resolutions. The following guidelines highlight the aspects of change management and problem reporting that are significant in demonstrating development assurance:

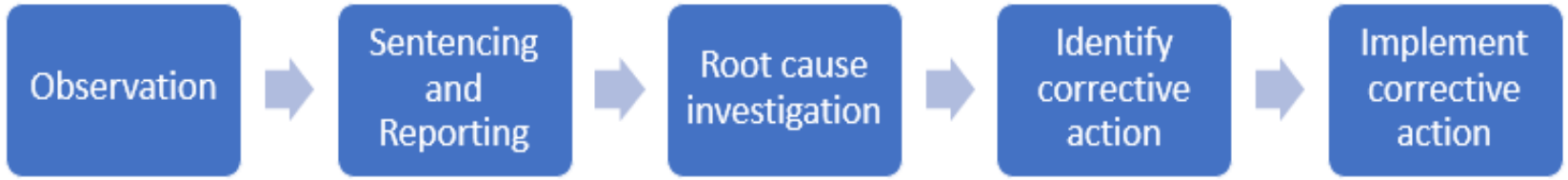
a. Means should be established to document changes and the resolution of problems,
b. Change control should ensure that any change to a system/item is appropriately identified by a change to its configuration identification,
c. Change control should ensure that changes to a system/item require applicable changes to the documentation
associated with the system/item,
d. Change control should preserve the integrity of a system / item by providing protection against unauthorized change.

In service issues (Failure analysis)

Detailed failure analysis of failed system/LRU is a crucial step in the product validation program. Without such analyses and feedback to the design team for corrective action, the product improvements may not be possible.
The key is to use the test results to provide insights into, and consequent control over, relevant failure mechanisms and to prevent them, cost effectively.

The purpose of doing failure analysis on samples which failed during the Inservice condition is to verify that the failures were caused by failure mechanisms that were not expected during the product qualification. Re-testing the system / product insures the validity of the qualification testing that was intended to focus on specified failure mechanisms that would occur under application conditions.

If a product with new technologies was developed, the failure mechanisms before the testing may not be clear. The failure analysis is a chance to reveal the actual failure mechanisms that caused the failures. Thus the right PoF models can be selected to calculate the reliability of the product based on testing results in the following step.



A root cause analysis (RCA) involves finding the root causes of a problem in order to identify and implement solutions. RCA treats the underlying causes of a problem instead of the surface-level symptoms of the problem itself.

In service issues (Failure analysis)

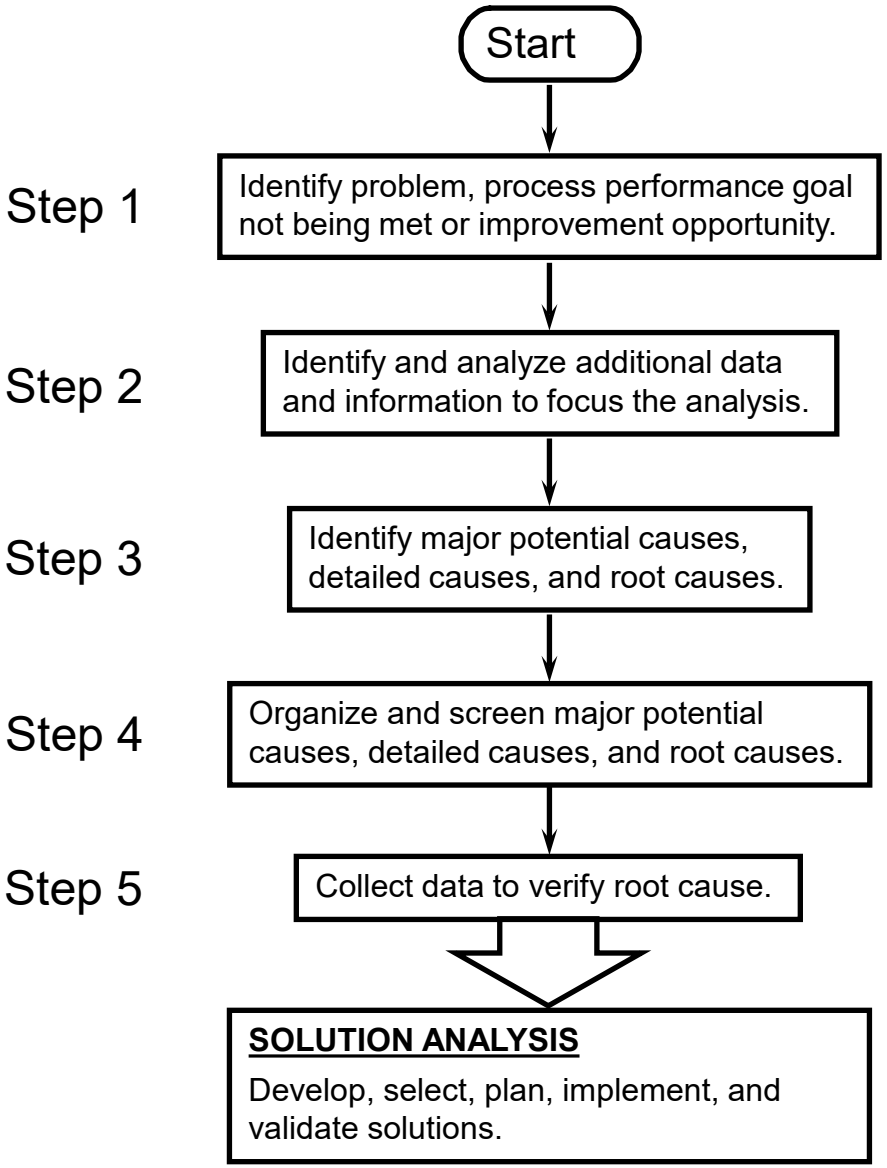
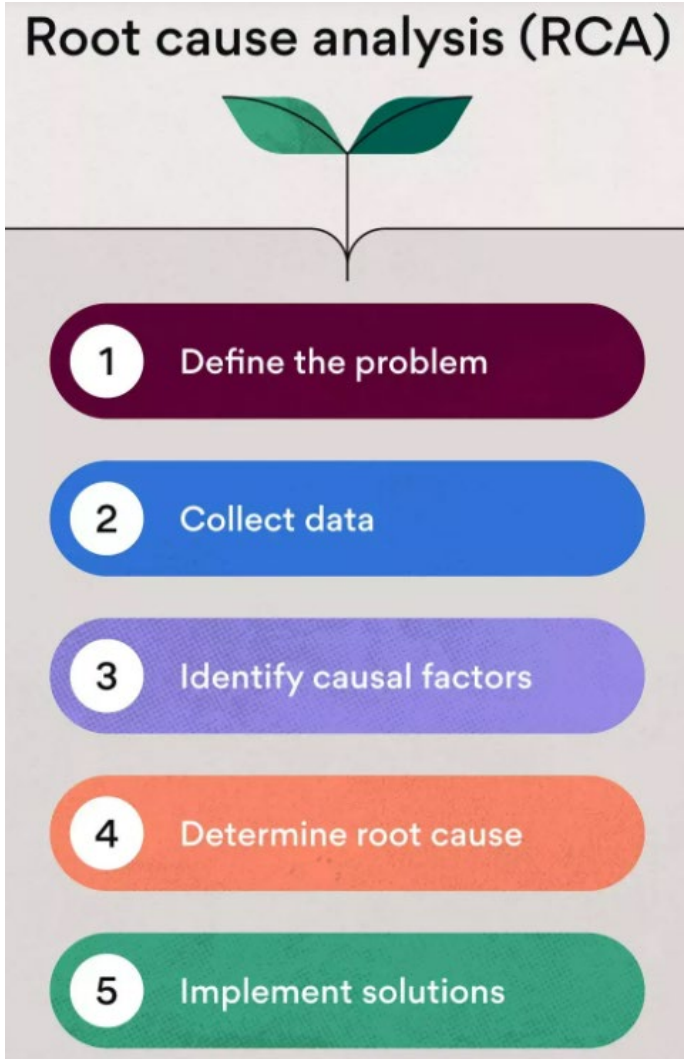
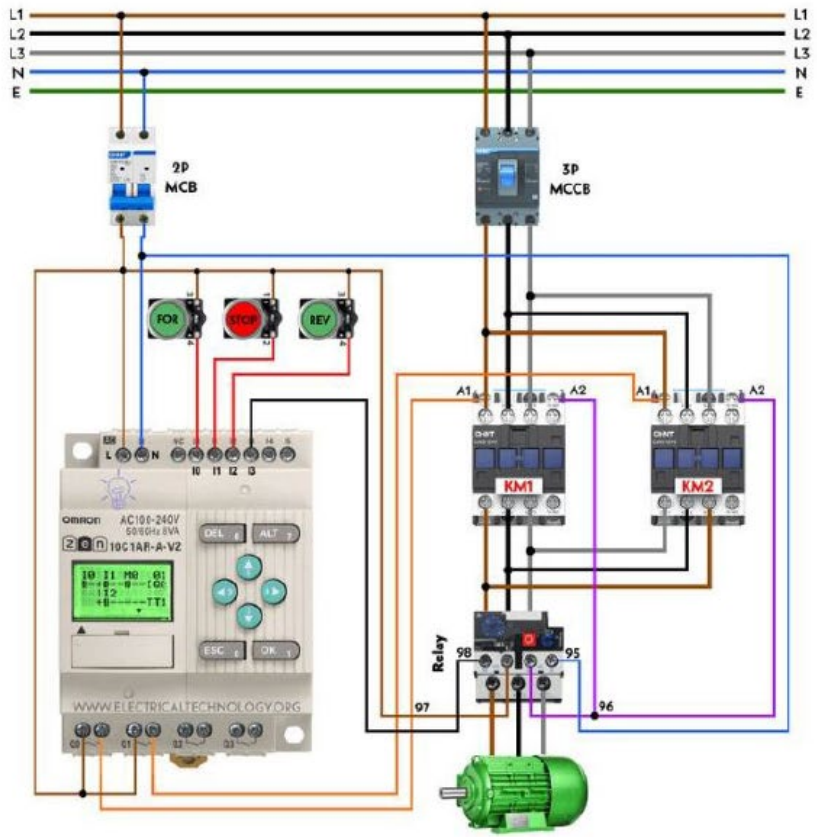


Figure-9: Failure analysis



Performance analysis of Scissor lift system

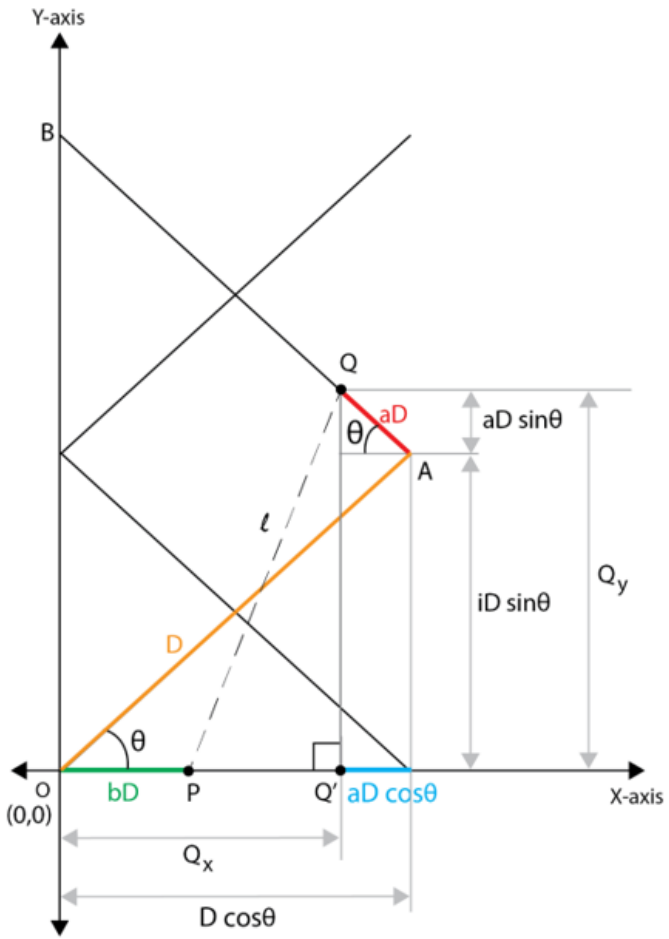


Performance Requirement: The Scissor lift system shall extend from lower to Up position within 30sec after activation of the push button to drive the motor.

INPUT COMMAND	FCE	PUSH Button signal transfer delay	0.015
		PLC Processing delay	0.020
	TRANSMISSION DELAY	Signal delay from PLC to RELAY	0.050
	RELAY	Relay contact operating delay	0.050
DRIVE	MOTOR	MOTOR Start up delay to reach full speed	0.050
	HYDRAULIC PUMP	Hydraulic motor delay to reach required pressure	0.030
VALVE & ACTUATOR	CHECK VALVE	Check valve lift up delay	0.020
	HYDRAULIC CYLINDER ACTUATION DELAY	Actuator travel delay	0.060
		Total (seconds)	0.295

Kinematic analysis of Scissor lift system

FIGURE 11



Let Q′ be the projection of point Q on the X-axis.
O is the origin, as described earlier.
Θ is the angle between any of the positively sloping scissor arms and the X-axis.
h is the height that the load has been lifted to.
i is the number of complete scissor levels immediately below point Q

(In this case i = 1, i.e. there is only 1 complete scissor level below point Q, but the derivation holds true for any value of i)

L is the length of the actuator, PQ
D is the length of the scissor arms.
AQ = αD |0 < α < 1

Let the distance between point Q and the hinge on the mobile side of the scissor lift, on the same arm as Q, be αD, where 0 < α < 1.
i.e. α is the fraction that AQ is of the full length of the arm AB.

Let $OP = bD \mid b \in R$

Let n be the number of levels of the scissor lift.
First, note that
$h = nD\ sin\theta$ ..... (2)

Since the scissor arm of length D at angle θ will have a vertical height of $D\ sin\theta$, and the total height h will be
by virtue of n such levels.

Now consider the co-ordinates of point Q, relative to origin O, as (Qx, Qy)

From Figure 11 it is clear that:
$Qd = (1 - a)D\ cos\theta$ ..... (3)
$Q4 = i + a\ D\ sin\theta$ ..... (4)

In ΔPQQ',

$PQ = l$ ..... (5)
$QQ' = Q4$ ..... (6)
$PQ' = Qd - bD$ ..... (7)

Substituting (3) into (7) and (4) into (6), we have:

$QQ' = i + a\ D\ sin\theta$ ..... (8)
$PQ' = 1 - a\ D\ cos\theta - bD$ ..... (9)

Applying the Pythagorean Theorem to ΔPQQ':

$$\overline{PQ}^2 = \overline{QQ'}^2 + \overline{PQ'}^2 \quad (10)$$

Substituting (5), (8) and (9) into (10):

$$l^2 = (i+a)^2D^2\ sin^2\theta\ +\ D^2[(1-a)\ cos\theta - b]^2 \quad (11)$$

$$\Rightarrow\ l^2 = (i+a)^2D^2\ sin^2\theta\ +\ D^2[(1-a)^2\ cos^2\theta - 2b(1-a)\cos\theta + b^2] \quad (12)$$

$$\Rightarrow\ \frac{l^2}{D^2} = [(1-a)^2 - (i+a)^2]\ cos^2\theta\ - 2b(1-a)\cos\theta + b^2 + (i+a)^2 \quad (13)$$

Since l/D is always positive, we may take a square root on both sides:

$$\frac{l}{D} = \sqrt{[(1-a)^2 - (i+a)^2]\ cos^2\theta\ - 2b(1-a)\cos\theta + b^2 + (i+a)^2} \quad (14)$$

Differentiating with respect to h:

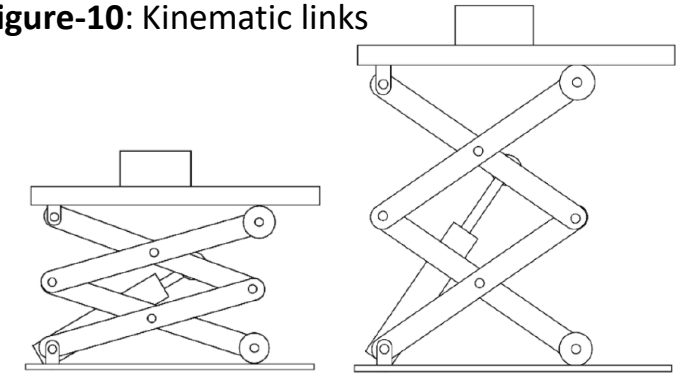
$$\frac{1}{D}\frac{dl}{dh} = \frac{1}{2}\frac{2b(1-a)\ sin\theta\ \frac{d\theta}{dh} - [(1-a)^2 - (i+a)^2]\ 2\ cos\theta\ sin\theta\ \frac{d\theta}{dh}}{\sqrt{[(1-a)^2 - (i+a)^2]\ cos^2\theta\ - 2b(1-a)\cos\theta + b^2 + (i+a)^2}} \quad (15)$$

To proceed, we must find an expression for $\frac{d\theta}{dh}$.

From (2), we have:

$$h = nD\ sin\theta \quad (2)$$

Figure-10: Kinematic links



Kinematic analysis of Scissor lift system

Differentiating (2) with respect to θ gives:

$$\frac{dh}{d\theta} = nD\cos\theta \tag{16}$$

Reciprocate (18) to give the required expression for $\frac{d\theta}{dh}$

$$\frac{d\theta}{dh} = \frac{1}{nD\cos\theta} \tag{17}$$

Substituting (19) in (17):

$$\frac{dl}{dh} = \frac{1}{n}\cdot\frac{b(1-a)\tan\theta - [(1-a)^2-(i+a)^2]\sin\theta}{\sqrt{[(1-a)^2-(i+a)^2]\cos^2\theta - 2b(1-a)\cos\theta + b^2+(i+a)^2}} \tag{18}$$

Reciprocate to give the required expression for $\frac{dh}{dl}$

$$\frac{dh}{dl} = n\cdot\frac{\sqrt{[(1-a)^2-(i+a)^2]\cos^2\theta - 2b(1-a)\cos\theta + b^2+(i+a)^2}}{b(1-a)\tan\theta - [(1-a)^2-(i+a)^2]\sin\theta} \tag{19}$$

Substitute (23) in (1) to obtain the final force equation

$$F = n\left(L+\frac{B}{2}\right)\frac{\sqrt{[(1-a)^2-(i+a)^2]\cos^2\theta - 2b(1-a)\cos\theta + b^2+(i+a)^2}}{b(1-a)\tan\theta - [(1-a)^2-(i+a)^2]\sin\theta} \tag{20}$$

In order to simplify the expression, we will define the following constants for any given actuator position:

$$A = 1-a \tag{21}$$
$$B = i+a \tag{22}$$

To generate the force expression for any actuator position, first obtain the constants A and B for that actuator position through (25) and (26), then substitute in the final equation:

$$F = n\left(L+\frac{B}{2}\right)\frac{\sqrt{(A^2-B^2)\cos^2\theta - 2bA\cos\theta + b^2+B^2}}{bA\tan\theta - (A^2-B^2)\sin\theta} \tag{23}$$

An alternate form involves defining three variables, A, B, and C, such that

$$A = (1-a)^2-(i+a)^2 \tag{24}$$
$$B = b(1-a) \tag{25}$$
$$C = b^2+(i+a)^2 \tag{26}$$

Here, the final expression becomes:

$$F = n\left(L+\frac{B}{2}\right)\frac{\sqrt{A\cos^2\theta - 2B\cos\theta + C}}{B\tan\theta - A\sin\theta} \tag{27}$$

Qualification Test (QTP)

QUALIFICATION TEST PLAN (QTP) FOR SCISSOR LIFT HYDRAULIC ACTUATOR

Category of requirement	Requirement	Qualification requirement	Test Type	Inspection	Similarity	Analysis
Temperature	The unit shall meet all ambient bay temperatures from -65 °F to +175°F. The unit shall meet all hydraulic fluid temperatures from +20 °F to +160°F. The unit shall operate continuously without physical or electrical degradation with hydraulic fluid temperatures of -40 °F to +225 °F applied at the inlet. The unit shall operate with rapid hydraulic fluid temperature change (temperature shock) from -40 °F to +160°F at a minimum rate of 20 °F per second. The unit shall meet continuous storage requirements when unpowered at an ambient temperature between -65°F to +160 °F. The Unit shall be designed to meet all performance requirements without physical or electrical degradation during and after exposure to the thermal environment defined by Section 4.5 RTCA/DO-160G, Category D2, except short-time and normal operating high temperature of 175 °F The unit shall be designed to meet all requirements without physical or electrical degradation after operating for 10 minutes with an overheated hydraulic fluid temperature of 275 °F applied at the inlet.	**Low Temperature – Performance**: The Unit has to be verified by test that it meets the performance requirements when supplied with hydraulic fluid at the minimum temperature +20 °F to +160°F. **Low Temperature - Operational** The Unit has to be verified by test that it operates without binding, chattering, or deterioration supplied with hydraulic fluid at the minimum temperature -40 °F to +225 °F applied at the inlet. **Low Temperature - Non-Operational** The Unit has to be verified by test that it meets all performance requirements following exposure to hydraulic fluid at the minimum temperature -65°F to +160 °F. **High Temperature - Performance** The Unit has to be verified by test that it meets the performance requirements when supplied with hydraulic fluid at the maximum +20 °F to +160°F. **High Temperature -** Operational The Unit has to be verified by test that it meets operates without binding, chattering, or deterioration when supplied with hydraulic fluid at the maximum temperature -40 °F to +225 °F applied at the inlet. **High Temperature - Survival** The Unit has to be verified by test that it operates without binding, chattering, or deterioration when supplied with hydraulic fluid at the maximum temperature for 10 minutes with an overheated hydraulic fluid temperature of 275 °F applied at the inlet.	**QT**			

Qualification Test (QTP)

QUALIFICATION TEST PROCEDURE (QTP) FOR SCISSOR LIFT HYDRAULIC ACTUATOR

1. **TEMPERATURE TESTING**

LOW TEMPERATURE TEST

A. Test Set-up

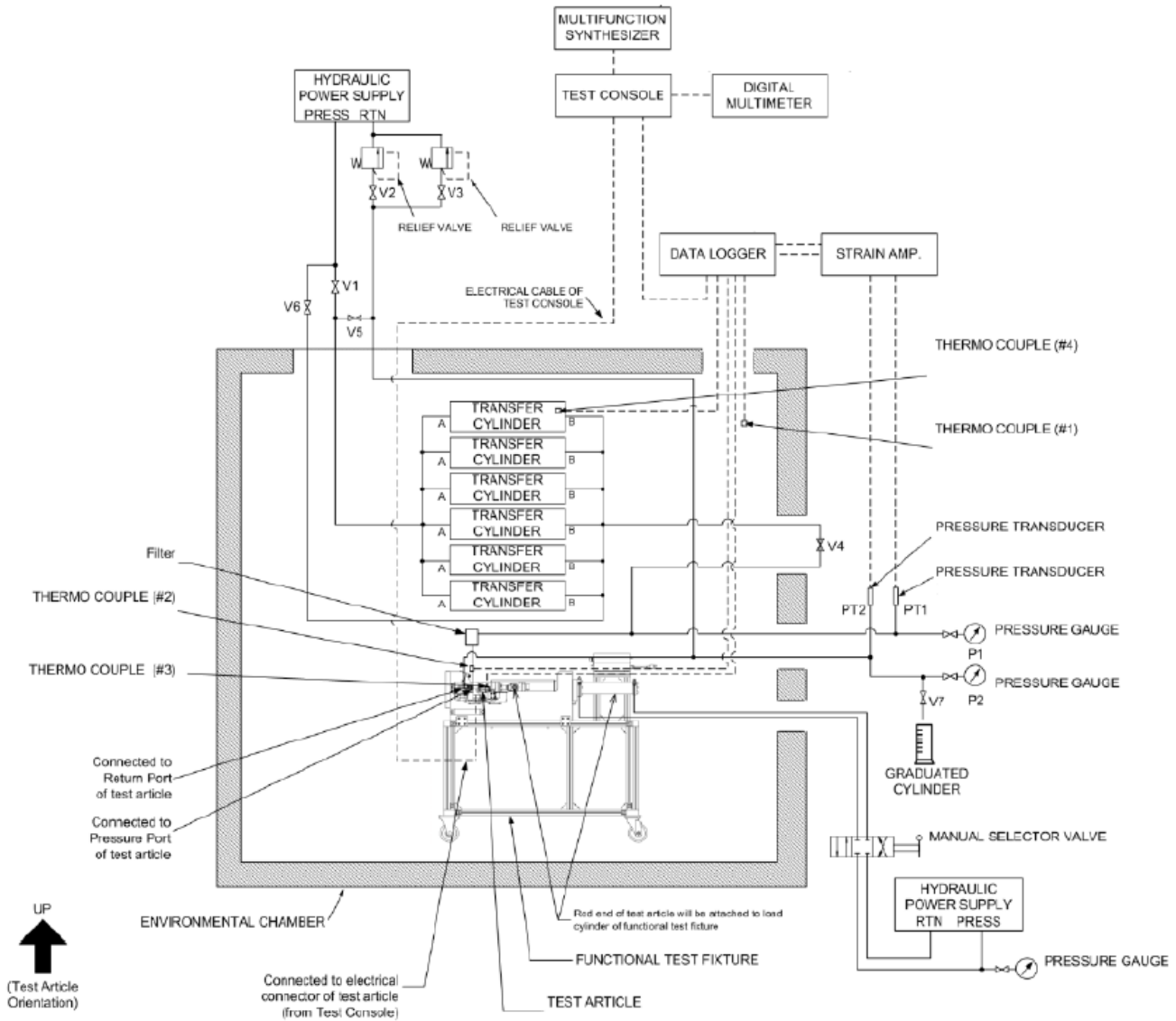
1) Test set-up per FIGURE-12 shown below. **L**inear **S**cale **A**ssy and Counter Box shall be removed from Functional Test Fixture.

2) This set-up is applicable to low temperature operational, performance and non-operational tests,

Test fixture / instruments / equipment to be used for this test are shown in the table below

FIGURE-12

FIGURE-12



Qualification Test (QTP)

QUALIFICATION TEST PROCEDURE (QTP) FOR SCISSOR LIFT HYDRAULIC ACTUATOR

Test Fixture / Instruments / Equipment	P/N	Note
Environmental Chamber		
Functional Test Fixture		
Test Console		
Hydraulic Power Supply		
Hydraulic Power Supply		
Pressure Gauge		0-5000 psig.
Pressure Gauge		0-300 psig.
(Pressure Gauge)		0-600 psig, alternate to 0-300 psig.
(Pressure Gauge)		0-1000 psig, alternate to 0-300 psig.
(Pressure Gauge)		0-1500 psig, alternate to 0-300 psig.
Pressure Transducer		
Pressure Transducer		
(Pressure Transducer)		
Strain Amplifier		
Data Logger		
Multifunction Synthesizer		
Thermocouple		
Manual Selector Valve		
Transfer Cylinder		
Transfer Cylinder		
Relief Valve		

LOW TEMPERATURE - NON-OPERATIONAL

Test Procedure

1) Open all valves except Valves V2, V3, V5, V6, and V7 closed.
2) Apply 50 ± 25 psig to all ports. Electrically de-energize the test unit.
3) Lower the chamber temperature to -65 ±4 °F and maintain until temperature stabilization of the test unit is attained. Temperature stabilization is defined that the temperature of a part of the test unit which has the longest thermal lag is changing no more than 4 °F per hour, but for not less than four (4) hours. The relative humidity need not be controlled. Record temperature value at start of test.
4) Monitor the external leakage.

Data Acquisition / Monitoring

Collect data / monitor the following data shall be monitored and recorded during each test:

- Supply pressure
- Return pressure
- Input command voltage
- Main RAM LVDT output voltage
- Solenoid Valve power voltage
- EHSV current

QUALIFICATION TEST PROCEDURE (QTP) FOR SCISSOR LIFT HYDRAULIC ACTUATOR

Record the temperature (ambient & fluid & test unit).

Monitor the external leakage from test unit.

Complete test data sheet shown below.
The sampling rate for all data and monitors shall be 100 Hz minimum. All data acquired at each test shall be recorded on test data sheet shown in

Test Requirements There shall be no external leakage.

Qualification Test Data Sheet

Ref Section	Check items	Requirement	Results
	General		
	Confirm data collected and stored per data recording and monitoring.	-	File name _____
	During test record if any monitor trips	-	File name _____
	Record the temperature	T/C #1 (Ambient) T/C #2 (Fluid) T/C #3 (Test Unit) T/C #4 (Transfer Cylinder)	File name _____
	Test Steps/data		
	Confirm Temperature stabilization	T/C #1 (Ambient) Lower the chamber temperature to -65 ±4 °F and maintain until temperature stabilization of the test unit is attained. Note: Longest thermal lag is change no more than 4 °F per hours, but not less than 4 hours.	Pass ___ Fail ___
	Monitor the external leakage.	There shall be no external leakage.	Pass ___ Fail ___

Qualification Test (ATP)

ACCEPTANCE TEST PLAN (ATP) FOR SCISSOR LIFT HYDRAULIC ACTUATOR

Category of requirement	Requirement	Qualification requirement	Test Type	Inspection	Similarity	Analysis
Proof Pressures	**System Proof and Burst Pressures (Section a)** The portions of the unit that are subjected to no greater than system pressure shall withstand a proof pressure equal to 1.5 times system pressure. The portions of the unit that are subjected to no greater than system pressure shall withstand a burst pressure equal to 2.5 times system pressure. **Proof and Burst Pressures in Localized Areas (Section b)** The portions of the unit that are subject to localized increases in pressure, such as snubbing and surges, shall withstand a proof pressure of 1.5 times the peak pressure. The portions of the unit that are subject to localized increases in pressure, such as snubbing and surges, shall withstand a burst pressure of 2.5 times the peak pressure. **Return Proof and Burst Pressures (Section c)** The portions of the unit that have fluid passages that are subjected to return pressure shall withstand a proof pressure equal to system pressure with zero pressure applied to the adjacent system pressure portions. The portions of the unit that have fluid passages that are subjected to return pressure shall withstand a burst pressure of 1.5 times system pressure.	**Proof Pressure Test** The supplier shall confirm the unit meets the supply and return proof pressures specified in Section a, b, c by applying each pressure independently and holding for two minutes. During proof pressure testing, the unit shall be cycled to modes as required to ensure that all components and passageways are subject to the applicable proof pressure for two minutes. **Supply Proof Extend** Connect the return port to drain and apply 3000 psig to the inlet port. Command the actuator to full extend, and allow the piston to bottom. Slowly increase the supply pressure to 4500 psig and maintain the pressure for two minutes in accordance to (**Section a).** There shall be no evidence of leakage or permanent set. **Supply Proof Retract** Connect the return port to drain and apply 3000 psig to the inlet port. Command the actuator to full retract, and allow the piston to bottom. Slowly increase the supply pressure to 4500 psig and maintain the pressure for two minutes in accordance to (**Section a).** There shall be no evidence of leakage or permanent set. **Return Proof** With the return port blocked, apply 3000 psig to the supply port and maintain the pressure for two minutes in accordance with Section C. There shall be no evidence of leakage or permanent set.	AT			

Qualification Test (ATP)

PRESSURE SYSTEM PROOF PRESSURE

The proof pressure test shall be conducted after removing Up-Float Check Valve & Load Relief Valve (if applicable) from test unit and installing the Dummy, Up-float Check Valve & Dummy, Load Relief Valve to test unit.

1) Test set up per 13.
2) Open all valves except V4, V5 closed.
3) Apply 3,000 psig and 50 psig to Pressure port and Return port, respectively.
4) Apply retract command to the Hydraulic actuator.
5) Apply 4,500 psig to Pressure port and hold for two minutes.
6) Reduce supply pressure to 3,000 psig and apply extend command to Hydraulic actuator.
7) Apply 4,500 psig to Pressure port and hold for two minutes.

Acceptance Criteria

There shall be no evidence of permanent distortion, external leakage or other damage.

RETURN SYSTEM PROOF PRESSURE

The following tests shall be conducted after removing Dummy Up-Float Check Valve (P/N TBD) & Dummy Load Relief Valve (P/N TBD) from test unit and installing the Up-Float Check Valve (P/N TBD), and Load Relief Valve (P/N TBD) to test unit.

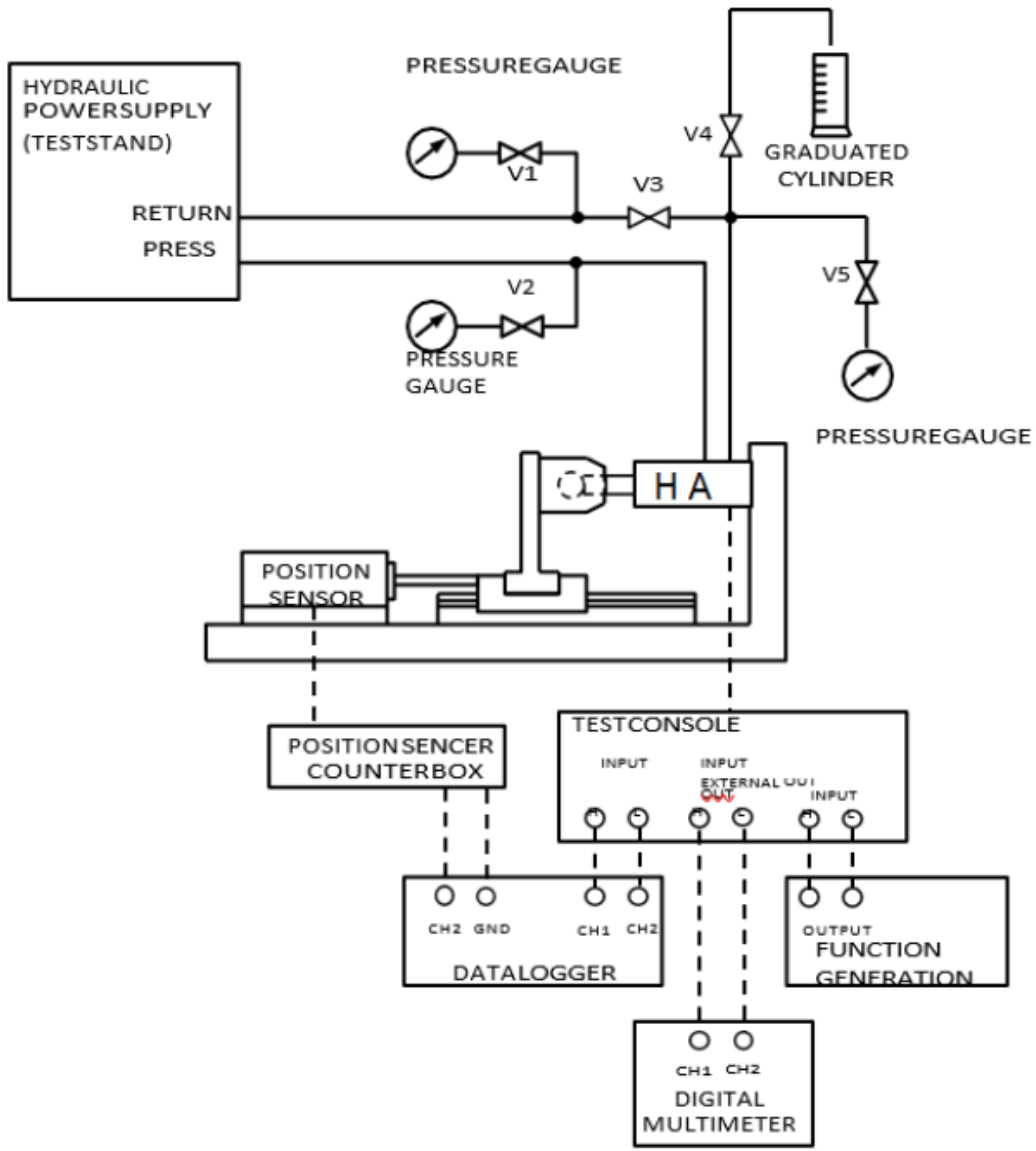
1) Test set up per FIGURE 13.
2) Open all valves except Valves V1, V3 and V4 closed.
3) Apply extend command to Hydraulic actuator and allow the piston to bottom.
4) Apply 3,000 psig to Return port and hold for two minutes.

CAUTION: Actuator may extend.

Acceptance Criteria

There shall be no evidence of permanent distortion, external leakage or other damage.

FIGURE 13



Compliance Matrix

Requirements ID	Requirements			Requirements Validity	Traceability / Rationale / Remarks	Product Verification				Compliance	Action / Comment
	Doc. Paragraph #	Requirements	Requirement Type			Product Verification Method	Product Verification Owner	Product Verification Evidence	Verification Comments		
T3-R-CV1	-	The function of the unit shall be to allow Hydraulic System Fluid to free flow/minimum resistance in one direction only, and prevent flow in the opposite direction.	Requirement	Valid	T2-R-1 T2-R-10	Test	Design / Analysis	Test Report		Intend to Compliant	
T3-R-CV2	-	It shall contain a minimum number of individual parts, consistent with the stated functional requirements.	Requirement	Valid	T3-R-CV1	Review	Design	Drawings, BoM		Intend to Compliant	
T3-R-CV3	-	The product shall be manufacture using material and process as per industry standard.	Requirement	Valid	T1-R-3	Review/Inspect	Design / Analysis / Manufacturing	Drawings, BoM, Analysis Report		Intend to Compliant	
T3-R-CV4	-	The unit shall meet all applicable environmental requirements without degradation during and after exposure to the following conditions.	Requirement	Valid	T1-R-3	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV5	-	The weight of the unit shall not exceed 500g.	Requirement	Valid	T2-R-9	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV6	-	Reseating of the valve shall occur between the limits of 55.16 kpa forward pressure and zero pressure	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV7	-	Cracking pressure of the valve shall be not less than 13.8 kpa nor greater than 55.16 kpa.	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV8	-	The unit shall be designed for rated flow of 0.1136 m^3/min.	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV9	-	The pressure drop shall not exceed 344.738 kpa at 0.1136 m^3/min flow at a temperature of 40 deg.C +/-30 deg.C.	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV10	-	Internal leakage in the reverse flow direction, measured after a two minute seating period shall be zero when subjected to pressure of 13790 kpa and 34.5 kpa consecutively.	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	
T3-R-CV11	-	No external leakage shall be seen when subjected to proof pressure of 1.5 times the max operating pressure.	Requirement	Valid	T2-R-6/7/8	Test / Analysis / Similarity	Design / Analysis	Test Report, Analysis Report, Similarity Report		Intend to Compliant	

Abbreviations / Acronyms

LRU : Line Replaceable Unit

FMEA: Failure Mode and Effect Analysis

QTP: Qualification Test Procedure / Qualification Test Plan

ATP: Acceptance Test Plan

TRR: Test readiness review

POF: Physics of failure

FMMEA: Failure Mode Mechanism and Effect Analysis.

SCD: Supplier Control Document / Specification control Drawing

CC: Change Control

PR: Problem Reporting

RCA: Root Cause Analysis

LVDT: Linear Variable Differential Transformer

TBD : To Be Decided

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Thank You