External Tank (ET)

CIL Closed Loop Verification System

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History
LM Closed Loop Verification System

- Post 51L evaluation of the LM CIL system showed a need to establish an accurate accounting system to assure External Tanks had been accepted to the latest CIL retention rationale prior to flight. To provide this assurance, LM developed and implemented the Closed Loop CIL Verification System.

- The Closed Loop CIL Verification System provides value added in the following ways:
  - Instantaneous checks of compliance to CIL Requirements
  - Assures LM and NASA that the latest FMEA/CIL Retention Rationale has been verified at DD-250/CoFR
  - Assures planning errors do not result in unverified CIL Requirements
  - Facilitates cost effective and accurate CIL verification
  - Allows expeditious comparison of “As Designed” to “As Planned” and “As Built” CIL requirements at any level of tank build
Overview

Failure Modes and Effects Analysis (FMEA)
Engineering identifies failure modes and root causes

Critical Items List (CIL)
Retention rationale (design, test, inspection and failure history of part)

CIL Verification System

"As Designed"
CIL Implementation Drawing (CID)

"As Planned"
Work Document Planning (MAF & Supplier)

"As Built"
Work Document Execution (MAF & Supplier)

An automated "As Designed" to "As Planned" to "As Built" closed loop verification system that ensures all "CI" prefix tests/inspections in the CIL Implementation Drawing (CID) have been accomplished and satisfied
CIL Implementation Drawing (CID)

Reliability Engineering

MMC-ET-RA04b
CRITICAL ITEMS LIST (CIL)
(7 Volumes)

Volume 1 - General
Volume 2 - Prop/Mechanical
Volume 3 - Electrical
Volume 4 - ASI
Volume 5 - TPS
Volume 6 - Press. Vessels
Volume 7 - Venting

MMC-ET-RA04a
Failure Modes and Effects Analysis
(7 Volumes)

Safety Engineering
Hazard Analysis

Engineering Changes

Systems Engineering

Engineering Requirements
CIL Implementation Drawing (CID)

Closed Loop
Electronic Database
**CID (cont’d)**

- Establishes “Roadmap” for all test/inspections required in the Critical Items List (CIL)
- Provides a means of accountability through the FMEA/CIL database
- Each critical test/inspection is identified in the CIL Document is identified with an unique “Find Number” which is traceable back to the FMEA/CIL
- This document identifies the find number, part number, revision, retention rationale, location, and whether or not a receiving acceptance plan (RAP) is required
CID (cont’d)

Find Numbers:

XX-X-XXXX.XXX.X

- Inspection Identification Number
- System Identification Number
  - P Propulsion
  - E Electrical
  - A ASI
  - T TPS
  - S Pressure Vessels
  - V Venting
  - U GUCA
  - H Safety Hazards
  - G Generic

Inspection Type

“CI” – those tests/inspections identified in the CIL that cannot be validated by subsequent tests/inspections or that validate any previous tests/inspections

“MI” – all other tests/inspections identified in the CIL
Michoud Assembly Facility (MAF) Process

Reliability Engineering
- MMC-ET-RA04b
  CRITICAL ITEMS LIST (CIL)
  (7 Volumes)
  - Volume 1 - General
  - Volume 2 - Prop/Mechanical
  - Volume 3 - Electrical
  - Volume 4 - ASI
  - Volume 5 - TPS
  - Volume 6 - Press. Vessels
  - Volume 7 - Venting
- MMC-ET-RA04a
  Failure Modes and Effects Analysis
  (7 Volumes)
- CIL DD250 Reports

Safety Engineering
- Hazard Analysis

Engineering Changes

Systems Engineering

Closed Loop Electronic Database

Fabrication Build Records & Traceability

MPP BUYOFFS
Quality Data Center

(AS DESIGNED)
Engineering Requirements
CIL Implementation
Drawing

(AS PLANNED)
Manufacturing
Process Plans
(MPPs)

(AS BUILT)
Hardware Fabrication
MAF “As-Planned” & “As-Built” Process Flow

LM QE plans CIL insp. in Manf. Process Plans (MPP) via HMS CAPP

As-Planned

HMS CAPP module updates “As-planned” records CILVS module

As-Built

LM QC inspectors verify & accept CIL inspections – SFM updates “As-Built” records CILVS module

HMS SFM module provides Manf. Process Planning interface for shop/QC floor personnel

CAPP = Computer Aided Process Planning  SFM = Shop Floor Manager
Supplier Process

Reliability Engineering

MMC-ET-RA04b
CRITICAL ITEMS LIST (CIL)
(7 Volumes)

Volume 1 - General
Volume 2 - Prop/Mechanical
Volume 3 - Electrical
Volume 4 - ASI
Volume 5 - TPS
Volume 6 - Press. Vessels
Volume 7 - Venting

MMC-ET-RA04a
Failure Modes and Effects
Analysis
(7 Volumes)

CIL DD250
Reports

Safety Engineering
Hazard Analysis

Engineering Changes

Vendor Data
Documentation Accountability System (DAS)

(AS DESIGNED)

Engineering Requirements
CIL Implementation Drawing

(AS PLANNED)

Supplier Work
Documents (CIL/PAR)

Supplier Hardware Fabrication

(AS BUILT)

Closed Loop Electronic Database

Systems Engineering

Supplier CIL/PAR maintained at Supplier

Supplier PQR Buyoff - CIL/PAR
Supplier

"As Planned" Process Flow

LM PQA plans Supplier
CIL insp. in CILVS

LM PQA Rep.
updates CILVS
planning
information
via Laptop

LM PQA prints CIL/PARs
and forwards to
Procurement (Material)

• Initial/latest
CIL/PARs
are incorporated into
supplier contract(s)

• Supplier
incorporates CIL
inspections into work
documents and
updates/stamps
CIL/PAR

LM PQA Rep. verifies CIL
inspections are
incorporated into work
documents and stamps
CIL/PAR

“As Planned”
CIL/PAR filed
at Supplier

CIL/PAR = Critical Items List Planning and Acceptance Record
Supplier

"As Built" Process Flow

Supplier builds and performs CIL insp. (Stamps CIL/PAR Form)

LM PQA Rep. performs CIL inspections and stamps CIL/PAR form

CIL/PAR maintained on file at supplier

LM PQA Rep. accepts CIL inspections in CILVS via Laptop
"As Planned" vs. "As Built" Comparison

- DD-250 Reconciliation Reports (by ET Effectivity)
  - Open Items
    - List "As Designed" records that are not planned
  - Measure of Performance
    - List all "As Planned" records
    - Provides evidence of "As Built" record matches
  - Proof of Performance
    - List records that need to be reconciled
      - Design without Build
      - Build without Design
      - Part Quantity Errors
  - ABHRS (As Built Hardware Reporting System)
    - Part Traceability

- Reviewed/Approved by DCMA and NASA
“MI” CIL Process

- “MI” CILs are currently planned into manufacturing and test documents per the CIL Implementation Drawing requirements.

- At present, there is no Closed Loop process for “MI” CILs.

- This may change, as our NASA Customer has requested Lockheed Martin to develop a method for closed loop accounting of “MI” CILs, and to provide an appropriate recommendation to contract requirements to accomplish this.
Summary

- Lockheed Martin was requested to develop a closed loop CIL system following the Challenger accident
- The system that was developed has proven to be very robust with minimal problems since implementation, having zero escapes in last 7 yrs (27 External Tanks)
- We are currently investigating expansion of the CIL Closed Loop system to include “MI” CILs
Safety! Mission Success! Our Top Priority!