

Naval Surface Warfare Center, Carderock Division

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## Navy Technical Publication - Process Requirements for Metal Directed Energy Deposition



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May 13, 2021

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Distribution Statement A: Approved for Public Release distribution is unlimited

## Why?

- Despite Wire Arc Additive Manufacturing being based off of traditional welding, and using much of, if not all of, the same physical equipment, current welding specifications do not address the design, control, and risks of the additive manufacturing processes.
  - The planned updates to the welding specs do not incorporate AM.

## Philosophy

- Requirements developed based on philosophy of welding (*Control essential elements through tolerances. Manage the procedure to achieve the desired mechanical properties.*) and casting (*emphasis on process control plans to achieve desired outcome*).
- Address potential for bead to bead or layer to layer parameter variability not available or utilized in PBF.
- Include considerations for hybrid processes, integrated process controllers and other developing technical improvements.

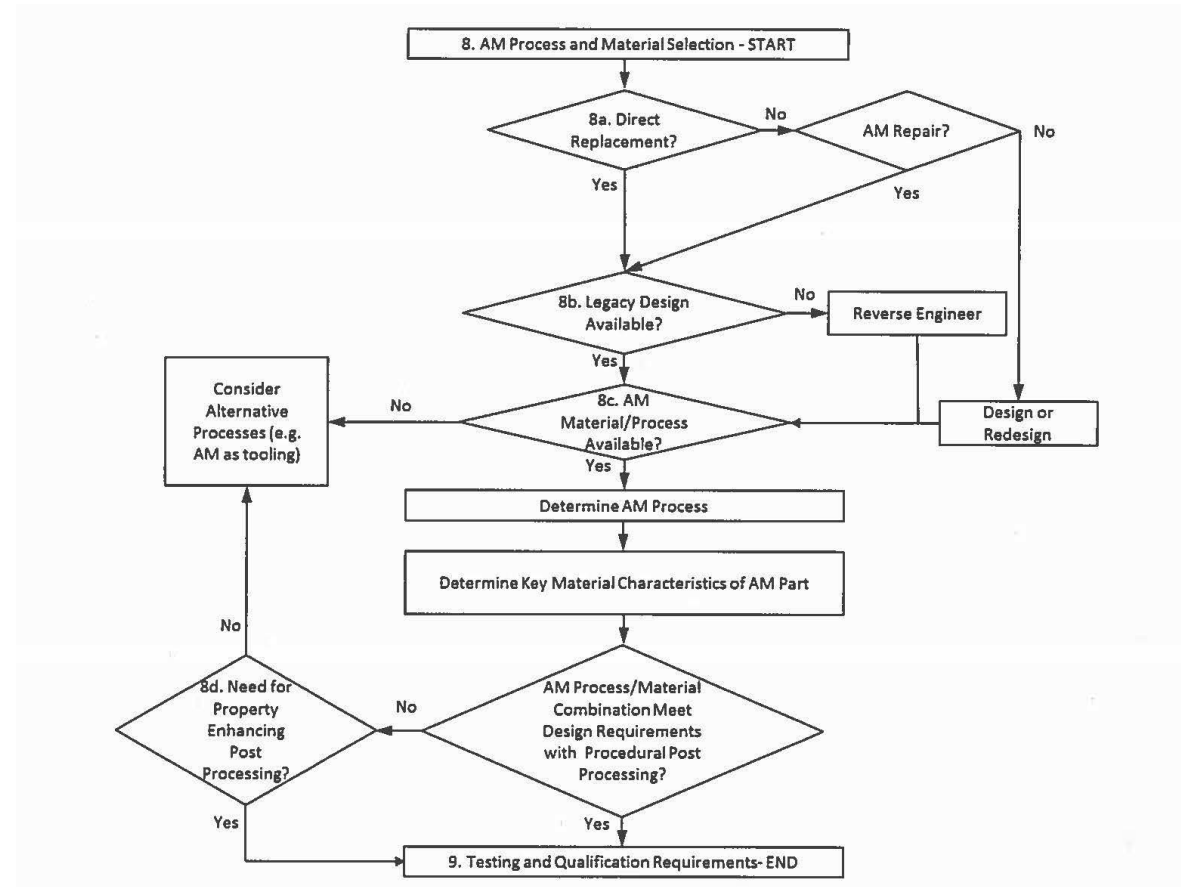
## Current Status

- Awaiting final issue from NAVSEA; anticipated June 2021

# Guidance on the Use of Additive Manufacturing Letter

## Overview:

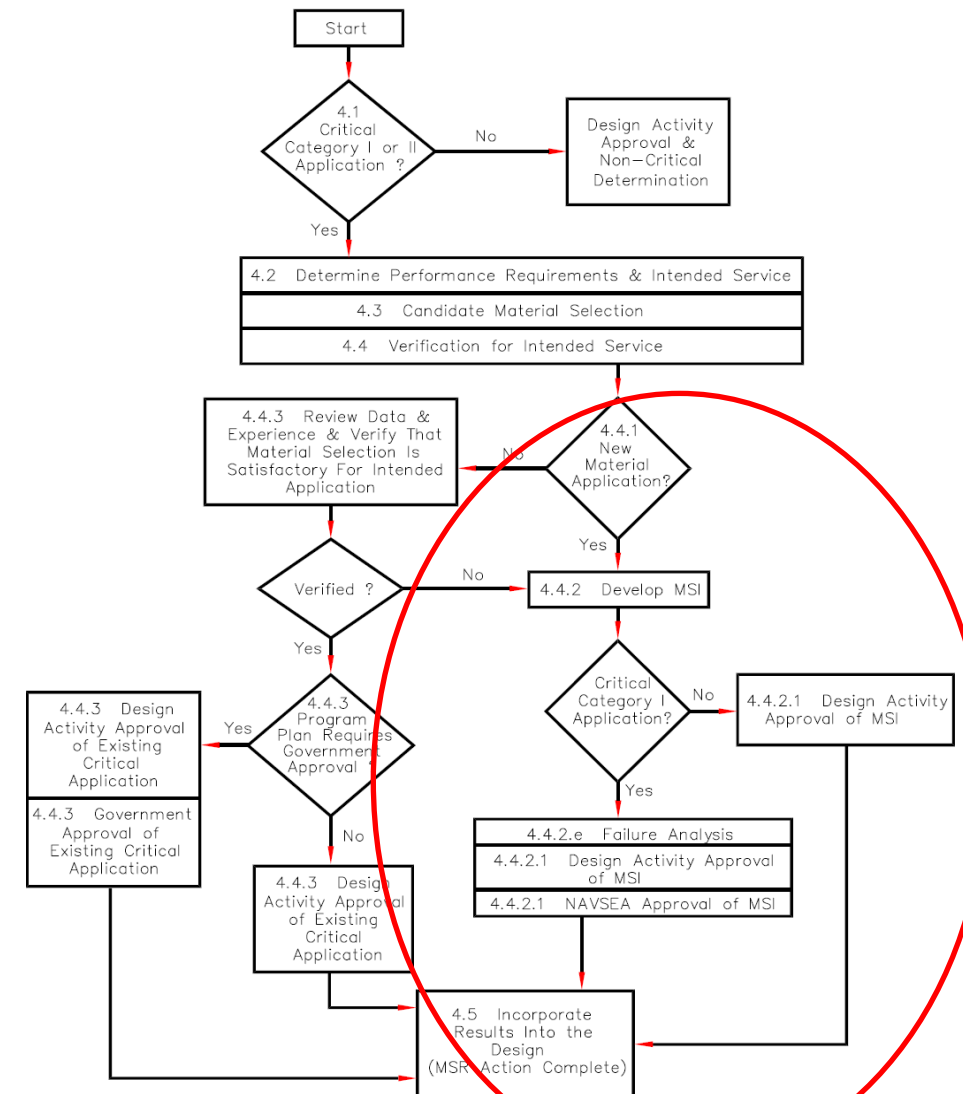
- Ser 05T/2018-024, Guidance on the Use of Additive Manufacturing Letter provides the considerations needed to evaluate if, when, and how to use AM for given applications and provides the NAVSEA approval requirements for differing risk severities.
- This document provides the considerations and requirements for utilizing AM in a NAVSEA application prior to executing the procedure qualification and part verification required in technical publications



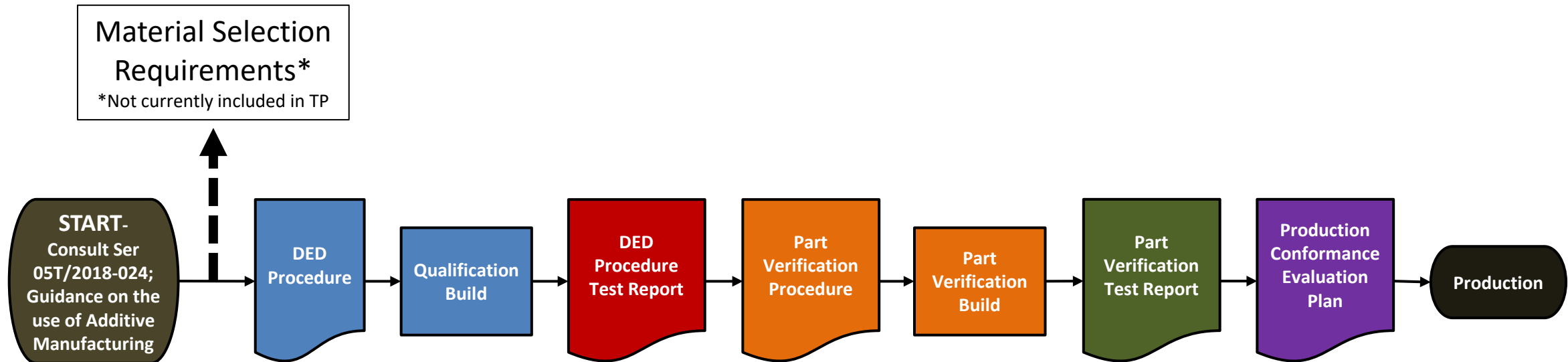


# Material Selection Requirements

- T9074-AX-GIB-010/100, Material Selection Requirements, is a NAVSEA Technical Publication that defines the metallic Material Selection Requirements (MSR) that must be met by each design activity responsible for the selection of metallic materials for ships and their systems.
- The MSR must be used for critical applications of materials and may be used or invoked for guidance in other applications.
- This flowchart is Figure 1 in the MSR document and illustrates the requirement flow for executing an MSR.
- Use of AM for any critical component is considered a “New Material Application”- requiring the process flow highlighted in the flowchart.



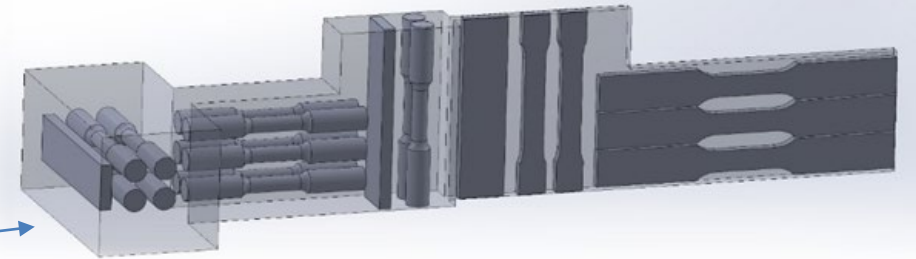
# DED Tech Pub- Major Requirements



This flow chart represents the major requirements and flow of the DED Tech Pub. Prior to executing the DED Tech Pub qualification, a component must be evaluated for severity level per 05T/2018-024; Guidance on the Use of Additive Manufacturing. The severity level dictates whether or not T9074-AX-GIB-010/100, Material Selection Requirements, is required.

# DED Procedure

- The **DED Procedure** is the document that specifies machine/process variables (*i.e.*, essential elements) and material acceptance criteria. Qualification of the **DED Procedure** requires deposition of a **Qualification Build** with generic geometry that is interrogated in order to confirm that material properties are acceptable. The DED Procedure must be submitted and approved by NAVSEA prior to executing any of the physical testing.
- More specific items include:
  1. NDE requirements
    - Required NDE tests are by dictated material group (Table 3-5)
    - Acceptance criteria must be developed from MIL-STD-2035 Class 1
  2. Destructive testing requirements
    - Required destructive tests are in Table 3-7
    - Based off of welding acceptance criteria – S and A groups
  3. Design of **Qualification Build** (aka “qual. block”)



Three blocks have been developed in partnership with EWI for different build “conditions”. These have been tested to show that the required mechanical tests can be pulled from each block.

## Flat, Non-Integrated Build Platform

- Designed for cases where the build platform will be removed after the completion of the build.

## Flat, Single-Sided Integrated Build Platform

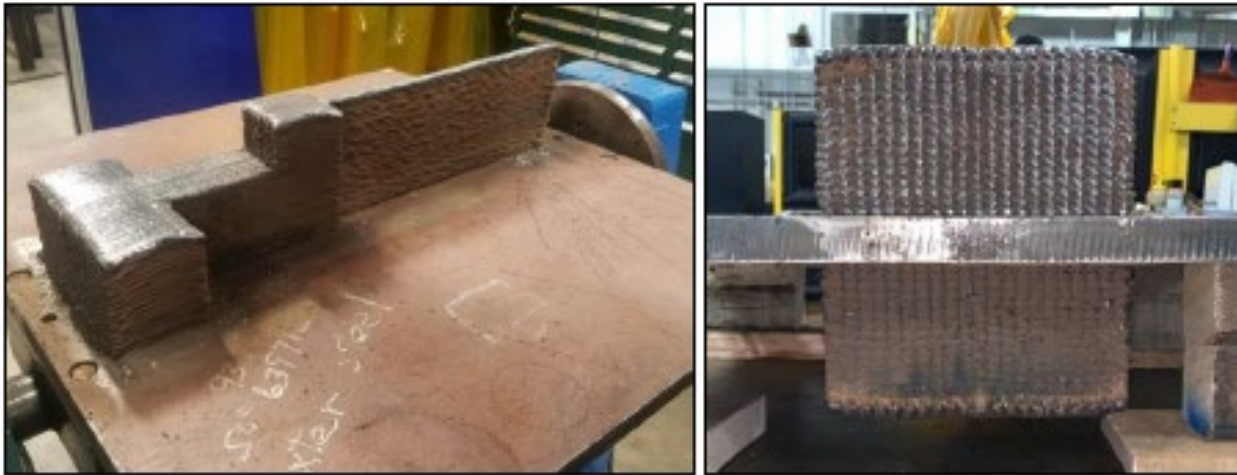
- Designed for cases where the build platform will be integral to the final part, or is an already existing component or subcomponent.

## Flat, Double Sided Integrated Build Platform

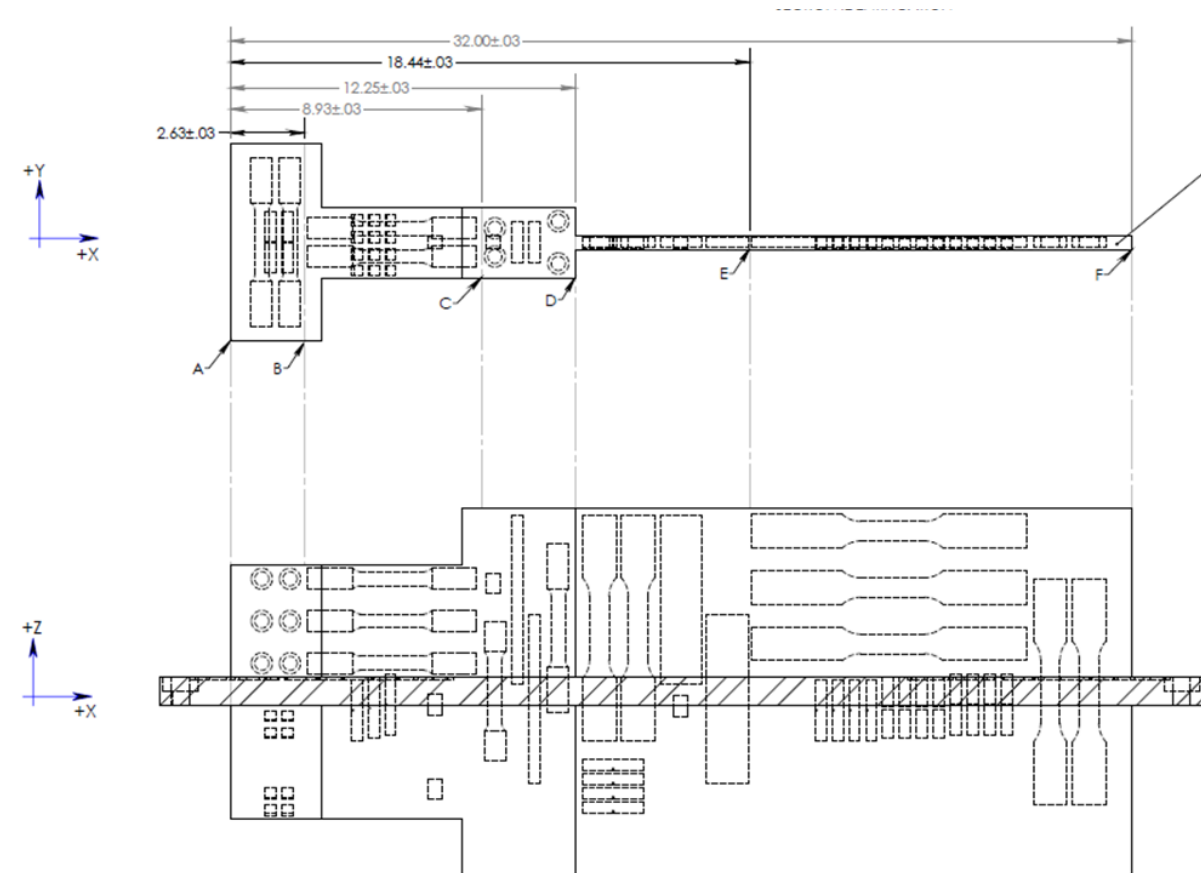
- Designed for case where the build process will occur on two or more sides of the build platform simultaneously where the build platform is integral to the final part, or is an already existing component or subcomponent.
- **The blocks are intended to have distinct microstructural zones representative of different potential build geometries to pull specimens from.**

Additional blocks are under development for curved build platforms and well as sub-sized blocks for lower deposition processes and size constrained systems.

# Example Qualification Block



Flat, double-sided integrated build plate qualification block; drawing and build produced at EWI





# DED Procedure Test Report

The **Procedure Qualification Test Report** is a document showing that the procedure used to deposit the **Qualification Build** produces material that meets or exceeds the acceptance criteria established in the **DED Procedure**.

When both the **Procedure Qualification Test Report** and **DED Procedure** are approved, the **DED Procedure** is considered qualified.

This qualification is only intended to be done once for a combination of deposition process and material. A qualified **DED Procedure** can be used for any build using the tested combination of process and material, irrespective of part geometry, as long as the essential elements of the process are maintained.

# Part Verification Procedure and Build

- The **Part Verification Procedure** is a document describing the procedure, build layout, nondestructive testing, destructive testing and specimen extraction locations, and any application-specific testing for the **Part Verification Build**.
- The **Part Verification Procedure** must be approved prior to executing the **Part Verification Build** and associated testing.
- The **Part Verification Build** is a sacrificial build produced using an approved **DED Procedure**. This build contains all the parts and witness coupons that would be produced during a single production build.
- Captures any unforeseen geometric effects on material performance and allows for component-specific testing (e.g., burst tests).

# Part Verification Test Report

- The **Part Verification Test Report** is a document containing the results of the **Part Verification Build** and associated testing.
  - This includes non-destructive, destructive, and component performance testing.
- Once **The Part Verification Test Report** is approved, the part is considered qualified.

# Production Conformance Evaluation Plan

- The **Production Conformance Evaluation Plan** is a document that contains the details of production builds, planned NDE testing schedules, planned destructive testing schedules, and specimen extraction locations.

**THIS MUST BE APPROVED PRIOR TO PRODUCTION.**

- Conformance Testing must be performed per the schedules defined in the **Production Conformance Evaluation Plan**



# Questions?