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NextGen Materials Standards Platform (NMSP) User's Guide

by Robert Jensen, Nate Bulcroft, Hallie Chavez, and
Seth Kimble

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NextGen Materials Standards Platform (NMSP) User's Guide

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ASM International

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| <p>Traditional specifications and standards, while effective for large-scale manufacturing, present challenges to the agility required by modern defense needs—particularly with the rise of additive manufacturing and short-lifecycle platforms. Updating these static documents is resource-intensive and often incompatible with rapid technological advancements. This project addresses these inefficiencies by modernizing standards development and management through automation, streamlined workflows, and integration of commercial expertise. MIL-PRF-32662, <i>Adhesive, High-Loading Rate, for Structural and Armor Applications</i>, is used as a test case. The resulting platform aims to reduce costs and delays associated with traditional standards, transforming them into dynamic, interactive resources. A key component is leveraging industry partnerships to identify dual-use applications, fostering sustainability and innovation. ARL, with ASM International, is establishing a long-term vision for the platform, targeting initial accomplishments by December 2025, including a comprehensive user's guide and exploration of future AI/ML integration. This effort supports DoD mission readiness and demonstrates fiscal responsibility by maximizing the impact of taxpayer investment.</p> | | | | | |
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1. Introduction and Overview

1.1 Introduction to Project

Specifications and standards provide an essential role in ensuring that materials, processes, and products reliably meet a minimum threshold of acceptance. Historically they have been developed to ensure conformance across a broad spectrum of potential experiences. While this one-size-fits-all static approach has been effective for large-scale manufacturing and long-term-use materiel, it has also functioned as a risk-mitigating strategy for so long that the risks introduced by changes are themselves now mitigated through long and arduous procedures. Updating and maintaining standards can require tremendous efforts by highly qualified personnel. This can be a barrier to modern needs for agility. For example, the rapid advancements in additive manufacturing have enabled a rise in small batch and ad hoc part production as well as in short-time-use disposable platforms that can be designed with a distribution of unique requirements to meet mission needs as they occur. The demands for timely qualification of these systems are incompatible with the one-size-fits-all approach of traditional specifications and standards, which impose unrealistic time and cost on small production batches and narrow requirement sets. Likewise, the time and cost associated with updating traditional standards is an impediment to keeping up with the rapid evolution in modern technologies.

The project and platform reported here directly address the inefficiencies hampering traditional standards development and management. By modernizing processes, automating updates, and facilitating seamless integration into user workflows, we seek to ensure DoD mission readiness for the current and future Army. By eliminating red tape and leveraging external commercial expertise, we also align with the recurring desire to streamline government operations. Our approach offers a clear pathway to reducing costs while simultaneously leading to improved outcomes by eliminating unnecessary delays and cost overruns that can result from updating traditional standards. Critically, this platform will help transform standards from static documents into dynamic, interactive resources that evolve with user needs. By reducing the burden on personnel and eliminating duplicative efforts, we empower government agencies to focus on their core mission, while demonstrating fiscal responsibility.

A significant aspect of this project is the emphasis on leveraging industry to increase scale and reduce cost of defense manufacturing by identifying dual-use applications with commercial value. This approach supports the long-term sustainability of our efforts, allowing for the rapid adoption of innovative solutions

and fostering a robust ecosystem of public–private partnerships. By aligning with goals of creating a more well-run and effective government, this platform serves as a vital tool for maximizing the impact of taxpayer investment and fostering innovation through strategic industry collaboration.

This report also details how the U.S. Army Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL), with the support of ASM International (ASM), plans to create a sustainable vision for the platform. Our approach minimizes risk of long-term failure, which can often happen with the departure of key personnel. The report then outlines the current phase of the project, detailing the specific accomplishments targeted for completion by December 2025. Following this, a comprehensive user’s guide is provided. Finally, the report explores the “Potential Future State of the Platform,” including the integration of AI/ML capabilities, leveraging the vast data generated to further enhance efficiency and effectiveness.

1.2 Platform Overview

The NextGen Materials Standards Platform (NMSP) is an open-source system originally designed to evaluate structural adhesives for military and commercial applications, specifically those intended to meet the rigorous performance standards of MIL-PRF-32662.¹ While initially focused on the acute needs of the adhesives standards process, it is crucial to emphasize the platform’s material-agnostic design and wide-ranging applicability. Any mechanical testing via load frame process that produces stress–strain curves to evaluate a mode of failure for material qualification would be applicable. This inherent flexibility extends the platform’s potential beyond adhesives, offering a standardized and efficient approach to material testing across numerous government and industry sectors. This broad applicability maximizes the return on investment and solidifies the platform’s value as a critical tool for modernizing government operations. It provides a new, streamlined pathway for materials developers to qualify their products, introducing much-needed transparency, efficiency, and visibility into a historically opaque process.

NMSP will allow users to submit product data to for analysis and “pre-approval” certification against DoD standards. Beyond this prequalification process, the platform also offers benchmarking and data visualization tools, giving users a clearer picture of where their product stands relative to others in the market. These insights help users identify areas for improvement, foster confidence in readiness for formal qualification, and strengthen product competitiveness.

By lowering barriers to entry and improving access to actionable data, NMSP empowers adhesive, and ultimately material, developers at all stages of development to participate in the qualification process. Its analytics provide meaningful feedback on how materials compare to benchmarks, enabling refinements that drive innovation and progress across the field.

The traditional process for qualifying materials is slow, redundant, and opaque, creating a bottleneck in the adoption of innovative materials. NMSP was developed to address these challenges and create an environment of transparency and accessibility for material developers. Specifically, the platform was designed to meet the following goals, shown in Table 1.

Table 1. Goals, challenges, and NMSP solutions.

| No. | Goal | Current challenge | NMSP solution |
|-----|--|---|--|
| 1 | Accelerate product qualification timelines | The DoD qualification process is slow and expensive, requiring repeated testing by multiple stakeholders. | Centralized submissions eliminate redundancy, helping users achieve qualification readiness faster. |
| 2 | Provide reproducible data | Traditional processes rely on summary-level data, making validation and reproducibility a difficult and cumbersome process. | The inclusion of raw data submissions—like load-displacement curves and failure surface images—ensure validation and create trustworthiness. |
| 3 | Improve accessibility | High costs and technical demands prevent participation by smaller vendors, research and development (R&D) teams, and universities. | An open-source framework lowers barriers, enabling broader participation in the qualification process. |
| 4 | Offer benchmarking and market insights | Vendors lack tools to compare their adhesives against others in the market, prolonging their ability to refine products and drive innovation. | Benchmarking tools visualize product performance relative to industry standards, with future iterations adding more robust insights. |

1.3 Who is NMSP for?

NMSP is designed for materials developers, including vendors, researchers, and academic teams, who are working with materials intended for military or high-performance commercial applications.

The platform is ideal for and designed for use by the following:

- **U.S. Government Agencies:** All government agencies seeking to streamline materials qualification and standards management.
- **Materials Vendors:** Companies seeking to qualify manufacturing-ready products for government or commercial use.

- **R&D Teams:** Innovators working on new material technologies, whether in early development or close to production readiness.
- **University Researchers:** Academic teams aiming to validate prototypes, demonstrate product performance, or attract interest for innovative materials.

1.4 Background on the Project

ARL developed the MIL-PRF-32662 anticipatory adhesives standard with a goal of achieving an ideal mix of pragmatism and results.² Research cited by Worcester Polytechnic Institute (WPI) indicates that proper integration of data science and testing requirements can reduce validation costs and time to develop new materials to one-third their current level.³ With this under consideration, ARL leveraged modern data science techniques to develop a standard that allows much simpler product testing and unlocks the potential for exceptional product performance. With ARL's guidance, PPG Industries Inc. used the standard to develop the PR-2930 adhesive, which would ultimately go on to win the Adhesive and Sealant Council's Industry Award for Innovation in 2020,⁴ and demonstrated potential for Guinness World Records' levels of adhesive strength.⁵

In parallel, ARL and WPI began developing the concept of a context-aware agile platform for the MIL-PRF-32662 standard in 2019.³ WPI's team of graduate students developed the Adhesives Dashboard, a Python-coded visualization of how users could interact with the standard. ARL brought ASM into the project to evolve the platform from academic prototype to commercial viability. ASM was further tasked to transition hosting of the platform to their servers and to develop a sustainability model to ensure reliable and resilient interface with the commercial sector.

ASM is the ideal partner to drive this development and sustainability effort. Their preexisting database business and platform development experience provides a solid foundation for rapid and effective implementation. As a material science agnostic nonprofit organization, ASM is uniquely positioned to ensure the platform's broad applicability and unbiased development. Their ability to be a self-sustaining nonprofit through the commercialization of its products and services guarantees the platform's long-term viability and reduces the reliance on continued government funding. This model aligns perfectly with the goal of maximizing the return on taxpayer investment. By leveraging ASM's expertise and established infrastructure, we can accelerate the development and deployment of this critical platform, ensuring its long-term success and contribution to government efficiency.

2. ASM Platform Sustainability Analysis

2.1 NMSP Sustainability Analysis

Overview of this Analysis

The purpose of this section is to review several of the factors that contribute to the financial sustainability and general viability of the platform after its initial development. The analysis continues to describe several commercialization models and proposes hypotheses along with steps for further study.

Central to our sustainability analysis is the supposition that significant cost savings can be realized by eliminating the need for redundant testing. This platform is designed to provide users with convenient access to existing qualification data, thereby avoiding the costly and time-consuming process of recreating experiments.

Specifically, we estimate that a single experimental qualification for adhesives against MIL-PRF-32662 incurs labor and materials costs of approximately \$50,000. This figure is based on an average testing period of 10 weeks, with weekly costs of \$5,000 and a typical execution of four tests. In industries such as aerospace, where stringent requalification standards demand a higher volume of tests and greater precision, costs can easily exceed \$1 million per qualification cycle.

The efficiency gain offered by this platform is substantial. Instead of initiating a full requalification process through physical testing, users can directly proceed to the next qualification stage if relevant data already exists within the platform. This avoids the significant financial outlay associated with recreating experiments.

Readers should understand that the commentary made here reflects ASM's current understanding, but this analysis will continually change.

2.2 Revenue Drivers

2.2.1 In General

The key source of revenue for any model, whether fees, subscriptions, or awards, will be most highly correlated with user engagement. There are two fundamental sources of engagement, though they are not mutually exclusive. The first is generated by user interest in the platform. The primary contributors to that interest are expected to be 1) the platform's convenience of use in allowing data input and analysis in the same system, 2) the branding value of meeting a DoD performance qualification, and 3) the increased sales channel opportunities generated by a

platform that facilitates buyer trust and the chance to reach buyers looking for alternatives.

The second method of generating engagement would be through government preference or requirement. The Government could over time begin to direct users to the platform, beginning with suggestion, transitioning to preference, and potentially reaching requirement. This could come from the purchaser or tester level (government employees in charge of purchasing or vetting) to begin with, but would hopefully reach more systemic heights in the future.

2.2.2 At Launch

Revenue drivers at launch will be limited given the relatively small audience for a single-standard platform, unless other government agencies rapidly adopt the platform. ASM would not likely proceed to full launch without commitments from customers or collaborators based on one of the models described in the following sections. Immediate revenue would have to be driven nearly entirely by these prelaunch sales.

2.2.3 At Scale

There are many more revenue opportunities once the platform reaches scale. With a few years of consistent usage ASM could curate data within the platform to be sold as packaged datasets. ASM has significant experience in selling datasets. Even though the adhesives space is still a new sector for the company, ASM should not find it prohibitively difficult to incorporate additional adjacent sectors into its data corpus. There are also opportunities to target the buyer side (i.e., private businesses who have an interest in purchasing adhesives). This could involve charging fees for purchasing agents to access and review information on the platform, or could come as a paid buyer's guide that could be created on a regular basis by ASM. Whether or not keeping the information freely available to potential purchasing agents would help leverage higher subscription or membership fees from platform participants still requires more study.

Another source of potential revenue in the more distant future would be through partnership or hosting plans with nongovernmental standards development organizations. Some are still struggling to find ways to enter the digital age. Few seem to be tapping into the full potential of anticipatory standards and could make use of the experience ASM will have developed at that point to expand into that space.

2.3 Cost Drivers

2.3.1 During Development

Development costs are largely characterized by a higher spend on staff time and very little spend on technology. The platform can be developed on a low-resource server that is highly affordable. Staff costs are primarily driven by the required developer and subject matter expert hours. Since most of the initial development will be complete by the end of the project's next phase (estimated to be December 2025), further development costs would fall into the "Additional Functionality" category.

2.3.2 At Launch

Commercial staff members will be more heavily utilized around platform launch, as they work to develop interest in the platform. This will lead to a temporary spike in labor costs.

2.3.3 At Scale

As the platform reaches scale—roughly 10 corporate accounts—the staff time will decrease significantly. Most of the standard bugs and use cases will already have been accounted for, so the platform will enter a maintenance phase. Technology costs will grow significantly by proportion (though they will be more than offset by the decrease in staff hours) as the platform grows to accommodate the increase in users and data.

2.4 Additional Functionality

2.4.1 In General

This section focuses on materially new functionality and features that could be incorporated into the platform but have not yet been funded. Basic quality of life and user interface improvements are considered maintenance and included in the ongoing costs discussed above. Two of the main potential areas for platform expansion include finite element analysis and microstructure analysis. Additional context around this potential will be covered in Section 9 of this report.

2.4.2 Costs

It would be reasonable to estimate that each major feature to be included in the platform will cost between \$100,000 and \$300,000 based on the development costs realized so far as part of this project. However, these costs could be greatly decreased if ASM did not have to include requirements gathering and process

building as part of its development cycle (i.e., if ASM was handed a concrete plan and simply had to develop it).

2.4.3 Potential Revenue

Additional functionality would make the platform more valuable to users, which would drive revenue. It is difficult to tell at this time whether that increase in revenue potential would be significant enough to firmly say that they would be worth the investment for subscription or membership gains alone though. But the commercial value of the data within the platform has the potential to skyrocket if some of these other domains are tapped.

2.5 Profitability Scenarios

2.5.1 In General

Each of these models should be considered by stakeholders throughout the next project phase, as there does not seem to be enough data to firmly rule any of them out entirely. There is also the chance for interplay between them. For example, the Government may opt to support the platform in tandem with further feature development over the first few years before it is financially stable on its own. Alternatively, lower-cost subscriptions to the platform for lower-volume users or universities could be combined with the larger membership fees of consortium members. To finalize an approach, more stakeholders need to be involved so that sentiment can be fully understood.

These models are made for the proposition that ASM would move the platform toward launch after the next phase of the project concludes in September 2025 with either no additional funding prior to launch or only a smaller bridge amount. The net costs included in the models include overhead in staff hourly rates (i.e., they are the total cost of those hours), but the amount of administrative cost directly tied to the platform (namely Finance and Legal) are not fully represented by those numbers. An estimate of this gap would be premature at this time, especially since the models do not have an overwhelming difference in their administrative costs.

2.5.2 Government Funding Model

The DoD could opt to fully fund the platform for the foreseeable future. While the ultimate goal of the platform would still be to transition to a self-sustaining model at some point in the future, there are valid reasons that it might be in the Government's best interest to plan on investing in the platform's regular operation.

First and foremost, the Government gains far more from the platform's existence than any other potential user. The platform certainly has the potential to generate significant value for other users, but most of that value will not be realized until the platform reaches a critical mass. Other aspects of user value, like prequalification benefits and the acclaim of meeting the standard, can be realized almost immediately by using the platform, but are difficult for potential users to measure until they see a longer track record of success. Second, funding the platform leads to control over the platform and its development. The quality of the standard and its potential to evolve government acquisitions are best served by having heavy government involvement in the platform.

Adding additional standards to the platform under this model would be a net benefit. It would add new markets of users and open additional Government funding mechanisms, potentially spreading budget burden across several departments. There is complexity with that sort of spread though. And regardless of whether the funding is concentrated or split across several sources, the project would remain threatened by changes in fund availability.

2.5.3 Subscription Model

ASM could simply sell subscriptions to the platform for an annual fee. A subscription-based model creates the highest amount of flexibility and independence for ASM but also carries the greatest short-term revenue risk. ASM has found that subscription-based services typically take several years to reach a significant market share. It is unlikely that ASM would be able to break even from its continued investment in this model for at least 5 years, which is not a tenable time frame.

While this model apparently carries the lowest administrative burden for ASM compared to the others, the gap is not as wide as one might expect. Annual renewals of even small subscriptions require significant effort on the part of the sales team and often involve license negotiations, vendor registrations, and other hurdles that take up work hours from the Finance and Legal functions.

This model is, however, the best equipped to handle the addition of multiple standards to the platform. It does not suffer from the Government funding challenges mentioned before, and ASM would not have to set up several different industry groups to support the varied standards. If the early revenue difficulties do not turn out to be prohibitive, this is likely the simplest long-term model for the platform.

2.5.4 Consortium Model

ASM could coordinate a consortium or committee with a membership made up of corporations and Government representatives. These members would pay an annual membership fee for access to the platform and a say in how it will be shaped. This gives more power to platform users and may make them more willing to pay for access to a platform that is still in its infancy.

There are a few examples that could serve as inspiration to this model. The Industrial Steering Group (ISG) of Metallic Materials Properties Development and Standardization (MMPDS) has an admirable track record of success. The founding ISG group was made up of just six companies. Through its first 17 years the group expanded at a rate of approximately 1.5 new members per year. Those are not staggering numbers, yet they have been able to thrive by making wise decisions about member tiers and fees.

The consortium model does pose its own risks though. While group collaboration can strengthen a project, it can also lead to additional bureaucracy that can slow development cycles and create unforeseen administrative burdens. It can be difficult to maintain even interest levels across participants, especially when there are a few particularly dominant personalities involved. Gathering the “true believers” in the product is the best way to hedge this risk, along with a comprehensive but clear governance structure that details responsibilities and ensures transparency.

2.6 Recommendations

2.6.1 Projected Best Model for Sustainability

Currently, it seems that the best commercial model is a hybrid of all the others. More specifically, a beginning launch fully funded by the Government through the first 2 years while user interest is developed, followed by a consortium model made up of the most interested users, and ultimately reaching a subscription-based model once the platform has reached a sustainable number of users and the committee members no longer feel their guidance is creating a net benefit.

The outlined approach avoids many of the problems that the three models demonstrate individually. It limits the risk of the platform not reaching a steady userbase by having early Government support, while eliminating the long-term need for Government awards to support operations. It creates user buy-in through collaboration but maintains an exit plan to a subscription model if the group becomes unnecessary or unwieldy.

2.6.2 Steps for Further Study

Now that the Government will have proof of concept for demonstration to potential users, more stakeholders must be brought into platform development. The DoD must begin pulling in other corporations that have submitted products for testing so that ASM can get a better sense of the market's potential interest in the platform. This can also serve as an opportunity for the Government to begin to message that the platform will, at some point in the future, be the preferred or even exclusive method for beginning the acquisitions process with DoD.

Similarly, action must be taken to form a working group of Government employees who are involved with standards beyond adhesives. This has long been a hope of the project team members and would be a major step toward understanding the full realm of how many standards would be a good fit for the platform.

3. Standards Improvement Machine Learning (ML) Platform Development Phase II

3.1 Statement of Work: Standards Improvement ML Platform Development Phase II

3.1.1 Objective and Scope

This Statement of Work aims to develop an intuitive application that will include the following features:

3.1.2 For DoD and Other Product Evaluators

- 1) A robust ML approach to verifying testing data by allowing testers (government, academic, industry, etc.) to upload their results onto the platform. The subcontractor will be able to provide “trust metrics” that will empower decision-makers without forcing them to conduct their own redundant, costly testing.
- 2) A feedback loop to dynamically improve upon standards. Standards owners will be provided with statistically generated recommendations on what tests may be inefficient or unnecessary to reach performance targets. The cost efficiency and end-user relevance of “dynamically adaptable” performance requirements will increase over time in comparison to legacy “static” comparisons.
- 3) A place to easily find alternatives. Potential buyers will be able to see what other products are achieving similar results, assisting buyers in evaluating bids and lowering the barrier to innovation. Moreover, finding viable

alternatives will help improve supply chain resilience for the DoD and other users. This will enable proactive Diminishing Manufacturing Sources and Material Shortages Management.

3.1.3 For Manufacturers

- 1) A convenient integration between the standard and user inputs. Users will be able to input data into the platform and receive immediate feedback on whether their data meets the standard's requirements.
- 2) A passive channel for marketing all a product's merits, one which extends directly to experts and purchasing departments alike.
- 3) Military performance verification. Manufacturers will benefit from the branding value of DoD performance qualifications when marketing and selling their products.

3.2 Tasks

The subcontractor shall propose the following tasks:

Having performed its initial analysis and porting of the code provided by WPI, the subcontractor will continue into a phase of exploration and strategic design toward developing the ASM NextGen Materials Standards Platform (the "Platform"). The goals of this phase are as follows:

- 1) Engage potential stakeholders to assess ideal collaborations and platform participants outside of the adhesives sector, including various branches of the Armed Forces if a working group is formed.
- 2) Assess and prioritize the potential technical features that the Platform could contain through collaborating with stakeholders and engaging subject matter experts. Evaluate what additional ML capabilities might be required to help the platform reach its potential and what the initial and continuing costs for such capabilities might be. Ultimately, features will be ranked on a scale from critical to superficial. Features will be developed as described in the Deliverables section.
- 3) Explore potential new expansions on the original concept in areas like finite element analysis and microstructure analysis, and how those developments might increase or decrease commercial viability of a minimal viable product.
- 4) Continue to update the total investment and timeline estimations that were drafted in the project's previous phase.

3.3 Deliverables

- 1) ASM will work with the following concepts and include creating roadmaps to achieve the following capabilities:
 - a. Developing a robust ML approach to verify test data.
 - b. Developing a feedback loop that provides statistically generated recommendations based on test data. This capability will highlight how this portion of the application will generate dynamically adaptable performance requirements over time.
 - c. Developing a method to allow for selection viable alternatives within the dataset population.
- 2) Within the application development space, ASM will deliver technical deliverables based on a prioritization schedule.
 - a. Prioritized technical tasks are ranked as following:
 - i. “Must have” (All should be included in the technical deliverable by end of project phase.)
 1. End User is able to interact with Mode of Failure data visualization
 2. End User is able to easily navigate the entire Platform via an interactive navigation bar
 3. ASM and DoD partner logos visible on the main Navigation
 - ii. “Should have” (Should be completed or have progress made towards completion.)
 1. The End User is presented with clear instructions on how to complete the Excel file for upload within the Excel file itself
 2. There are multiple levels of Self Qualification. Each time an End User provides the right information, a check box will appear next to the following “achievements:” I. Vendor Self Qualified II. IS Certified Lab III. DoD Lab Validation IV. ARL Qualified
 3. End User is able to interact with Load Displacement Curve data visualization
 4. End User is able to see who qualified the data (end user account), how many other end users qualified the data, when the data was qualified, where it was qualified, and who has used the material

5. Ability to download their own self-qualified data in Excel or .csv
- iii. “Could have” (Potential deliverables)
1. End User is able to interact with Knock Downs data visualization
 2. The End User is able to see the status of qualification packages on their navigation bar
 3. End User is able to correct errors within their qualification packages on the Platform after submitting for Self Qualification
 4. End User is able to correct errors within their qualification packages on the Platform prior to submitting for Self Qualification
 5. End User receives an email from ARL or ASM confirming they successfully completed their digitized record upload and are now self-qualified once all the proper fields are completed and the End User hits submit for completion
 6. End User is able to start a new qualification from the Navigation bar
 7. Ability to download self-qualified data from other vendors in Excel or .csv for all end users
 8. Ability to download PDF performance specs for all users

4. Structural Adhesive Evaluation Platform User Guide

4.1 Getting Started

4.1.1 Preparing for Submission

The first and most essential step in using NMSP is preparing a complete and thorough submission. This includes compiling testing data, processing metadata, and supporting documentation to ensure that your adhesive aligns with MIL-PRF-32662¹ standards. It is recommended that you download and review the **Performance Specification (MIL-PRF-32662¹)** to understand baseline performance criteria.

Why This Step Matters:

- **User Preparation Timeline:** Preparing the necessary data, running experimental tests, and compiling the required metadata **can take up to 6 months**, especially for users starting from scratch or those with limited existing data.
- **Resource-Intensive Validation:** While validation is conducted by the NMSP team, the quality of your submission will determine the efficiency and accuracy of the review process.
- **Reproducibility and Trust:** Metadata and testing results must be detailed, precise, and formatted correctly to ensure reproducibility.

Callouts:

- It is critical you take the time to ensure your data is complete, accurate, and formatted correctly. **Missing or incomplete metadata will cause delays or rejection.**
- Open the attachments pane in the MIL-PRF-32662¹ PDF file, which contains useful background and technical information.
 - In Adobe: Go to > View > Show/Hide > Side panels > Attachments, as shown in Figure 1.

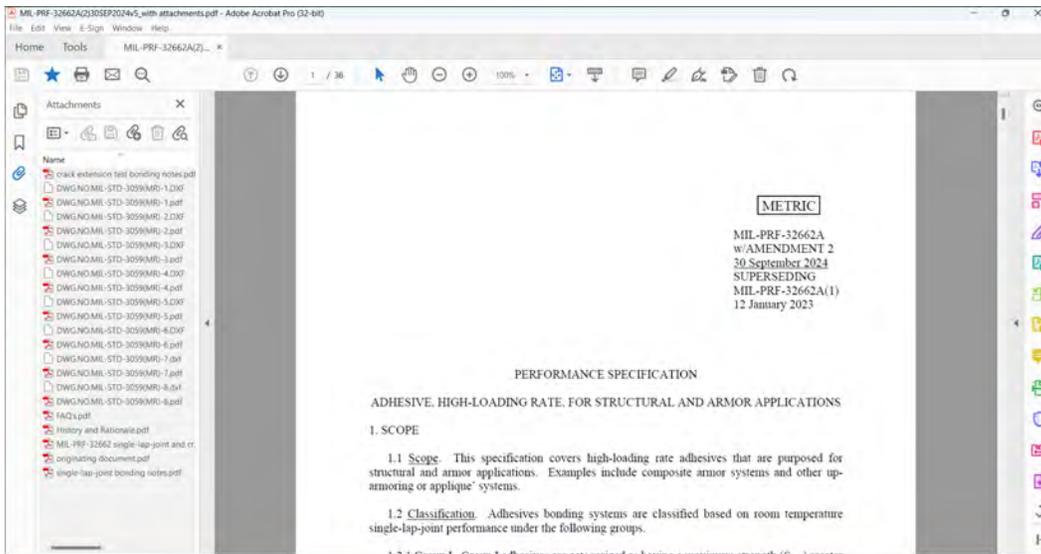


Figure 1. The attachments pane in the MIL-PRF-32662¹ PDF file.

4.1.2 What You Will Need for a Complete Submission

To submit your adhesive for evaluation, the following materials are required:

- 1) **Product Entry Form**, templated Microsoft Excel spreadsheet.
- 2) **Testing Data**, including the following:
 - a. Load-displacement curves
 - b. Failure surface images
 - c. Crack length measurements
 - d. Relevant metadata
- 3) **Technical Data Sheet (TDS)**
- 4) **Safety Data Sheet (SDS)**
- 5) **Manufacturing Readiness Level (MRL) Assessment⁶**
 - a. Early-stage products (MRL 4): include proof-of-concept data.
 - b. Production-ready materials (MRL 9 and 10): provide comprehensive test results.

4.1.3 Time Considerations

Preparation Timeline: Users should expect to spend up to 6 months preparing their testing data, metadata, and documentation before submitting to NMSP.

Submission Review Timeline: The time required for the validation process is currently 30 days and may vary depending on submission quality, readiness, and queue volume.

4.1.4 Proprietary Information Protection

Here is how your proprietary information is protected on NMSP:

- **Secure Submission Handling:** All submissions are processed in a controlled, secure environment to prevent unauthorized access. Adhesive formulations, manufacturing details, and proprietary testing data are never shared publicly.
- **Anonymized Benchmarking:** Benchmarking tools only display anonymized, aggregated performance data, ensuring no specific product details are exposed.
- **Restricted Access:** Testing outputs, such as load-displacement curves or failure images, are shared exclusively with NMSP reviewers and are not made available to other users.

NMSP balances the need for benchmarking and transparency with strict protections for proprietary information, ensuring users can trust the system without fear of compromising intellectual property.

4.2 Platform Acceptance Process

This section outlines the step-by-step process users must follow to prepare their adhesive for submission on NMSP (Table 2). Each step highlights user responsibilities and actions required to ensure a successful submission.

Table 2. Preparing adhesive for submission on NMSP.

| | | |
|--------|--|--|
| Step 1 | Download MIL-PRF-32662 and review requirements | Access the specification document to understand the required testing parameters and standards for structural adhesives. |
| Step 2 | Conduct product testing | Perform testing in line with the specification's requirements and concurrently document results using the provided data sheet (CSV template). |
| Step 3 | Compile required files and metadata | Collect all testing outputs, including failure surface images, crack length measurements, and load-displacement curves, alongside process metadata (e.g., curing conditions and surface prep). |
| Step 4 | Submit files via secure email | All data and documentation must be submitted securely via the designated email process. (For details on this process contact usarmy.apg.devcom-arl.list.carc@army.mil .) |
| Step 5 | Monitor submission status | Track the status of your submission. If revisions are required, follow reviewer instructions for updates. |

5. Product Testing and Documentation Requirements

Before submitting an adhesive for evaluation in NMSP, users must conduct standardized tests and compile supporting documentation to validate product performance and testing conditions. This section outlines the required testing outputs, documentation, and standards necessary for a successful submission.

5.1 Required Testing Outputs

To ensure comprehensive evaluation, the following outputs are required for each adhesive product.

5.1.1 Load-Displacement Curves

Load-displacement curves graphically represent the relationship between the applied load (force) and the corresponding displacement (movement) in the adhesive joint. These provide critical insights into the adhesive's mechanical performance under cleavage stress.

- Specifications:
 - **Quantity:** 15 curves (one per tested sample across Room Temp Dry, Elevated Temp, and Hot-Wet conditions).

- **Data Required:** Numerical values for load (N) and displacement (mm), plotted continuously.
- **Measurement Standards**
 - ASTM D1002⁷: Standard test method for apparent shear strength of single-lap-joint adhesively bonded metal specimens by tension loading (metal-to-metal).
 - Requires continuous data recording during testing.
 - **Purpose:** determines the adhesive's strength, elasticity, and failure point under load.
- **Key Requirements**
 - Ensure evenly spaced data points to capture the adhesive's full performance curve.
 - Label axes with units (N for load, mm for displacement).
 - Avoid missing or incomplete data points.

5.1.2 Failure Surface Images

- High-resolution images of failure surfaces reveal adhesive failure modes (adhesive, cohesive, or substrate failure), aiding in performance evaluation.
- Specifications include:
 - **Quantity:** 15 images (one per tested sample).
 - **Image Standards**
 - Minimum resolution: 300 dpi (dots per inch).
 - Formats: JPEG or PNG.
 - **Measurement Standards**
 - ASTM D1002: Standard test method for apparent shear strength of single-lap-joint adhesively bonded metal specimens by tension loading (metal-to-metal) for assigning the mode-of-failure.
 - **Purpose:** Provides visual evidence of bond quality and failure characteristics.
 - **Key Requirements**
 - Scan as 300 dpi, TIFF (preferred) or JPG image format.
 - Ensure images clearly show the entire failure surface.
 - Use proper lighting and focus to highlight details.
 - Match images to corresponding test condition and metadata.

5.1.3 Crack Length Measurements

- Crack length measurements assess the propagation of cracks under stress, a key parameter for fracture toughness evaluation.
- Specifications:
 - **Quantity:** 15 measurements (one per tested sample).
 - **Data Required:** Crack lengths in millimeters (mm).
 - **Measurement Standards**
 - SAE AMS 3695⁸: adhesive film, epoxy-base, for high durability structural adhesive (used for crack extension test specimen geometry).
 - **Purpose:** Evaluates resistance to crack propagation under Mode I loading conditions.
 - **Key Requirements**
 - Record measurements to the nearest millimeter.
 - Include crack length data in metadata or CSV file.
 - Ensure alignment with corresponding failure surface and test condition.

5.2 Required Documentation

Supporting documents are critical for validating product characteristics and testing conditions. All files must adhere to specific formats and naming conventions to ensure smooth processing (Table 3).

5.2.1 Summary of Required Files

Table 3. Supporting document formats and naming conventions.

| File type | Quantity | Details | Required format | File naming convention |
|----------------------------|----------|---|-----------------------|---|
| Load-displacement curves | 15 | CSV files with Load (N) and Displacement (mm) for each test condition. | CSV | VendorName_Date_TestCondition_SampleID.csv |
| Failure surface images | 15 | High-resolution images corresponding to each sample and condition. | JPG or TIFF (300 dpi) | VendorName_Date_TestCondition_SampleID.jpg |
| Crack length measurements | 15 | Manual measurements per sample. Include in metadata or submit separately. | CSV | Part of overall CSV or VendorName_CrackLength.csv |
| Technical Data Sheet (TDS) | 1 | Comprehensive product details, including performance characteristics. | PDF | VendorName_TDS.pdf |
| Safety Data Sheet (SDS) | 1 | Document for safety compliance. | PDF | VendorName_SDS.pdf |
| Product entry form | 1 | Includes contact info, lot IDs, and product descriptions. | PDF or Word | VendorName_AdditionalInfo.pdf |

5.2.2 Documentation Templates

- MIL-PRF-32662 sample data sheet (contact usarmy.apg.devcom-arl.list.carc@army.mil)
- Technical Data Sheet (TDS) template (contact usarmy.apg.devcom-arl.list.carc@army.mil)
- Safety Data Sheet (SDS) template (contact usarmy.apg.devcom-arl.list.carc@army.mil)
- Product entry form (contact usarmy.apg.devcom-arl.list.carc@army.mil)

5.3 Metadata

5.3.1 Metadata Requirements

Metadata must be submitted as part of the accompanying CSV documentation. Below are the key fields and their descriptions, along with examples to illustrate the expectations.

5.3.1.1 Surface Preparation Details

Ensuring reproducibility of bond quality across different laboratories requires comprehensive surface preparation metadata.

- **Information Needed**
 - Surface material and treatment type (e.g., phosphoric acid anodization etch).
 - Acid concentration and temperature.
 - Voltage applied and duration of treatment.
 - Rinse process description (e.g., duration, water type).
- **Common Issues to Avoid:** Omitting critical steps or conditions, which can lead to irreproducible results.

5.3.1.2 Adhesive Processing Parameters

Validating uniformity in processing is essential for ensuring consistent adhesive performance.

- **Information Needed**
 - Adhesive type, batch, and lot numbers.
 - Mixing ratio and curing conditions (temperature, pressure, and time).
- **Example:** *“Adhesive cured at 250 °F for 120 min under 500 psi pressure.”*
- **Common Issues to Avoid:** Lack of clarity in curing steps.

5.3.1.3 Joint Preparation and Assembly Details

Providing detailed joint preparation and assembly information ensures consistency in adhesive bondline characteristics.

- **Information Needed**
 - Thickness of adhesive bondlines (e.g., measured in millimeters).
 - Assembly conditions, including humidity and temperature.
 - Fixture or alignment details during assembly.
- **Example:** *“Bondline thickness was 0.5 mm, assembled at 50% humidity and 23 °C.”*

- **Common Issues to Avoid:** Incomplete descriptions that overlook environmental factors.

5.3.1.4 Testing Metadata

Comprehensive testing metadata ensures consistency between testing and reported results.

- **Information Needed**
 - Testing conditions, such as speed, temperature, and duration.
 - Equipment calibration details and standards followed.
 - Batch and serial numbers for test samples.
- **Common Issues to Avoid:** Missing calibration data or inadequate documentation of test conditions.

5.3.2 The Importance of Metadata

Metadata offers the transparency needed to validate and trust vendor-submitted results. With the right metadata, the product should be able to be replicated with the same results. This eliminates doubts, accelerates approvals, and provides a clear value proposition for all parties involved.

For vendors, this is an opportunity to prove product reliability and streamline acceptance into operational use. Robust metadata demonstrates a commitment to quality and ensures the data is future-proof for industry needs.

5.4 Testing Methodology and Standards

Adherence to standardized testing methodologies ensures consistency, reliability, and comparability of submitted data. Below are the relevant standards referenced by MIL-PRF-32662¹ (Table 4).

Table 4. Testing standards.

| Test | Standard | Description |
|------------------------------|---------------------------|--|
| Single lap joint | ASTM D1002 ⁷ | Evaluates fracture strength under cleavage stress. |
| Crack extension measurements | SAE AMS 3695 ⁸ | Mode I tensile strain energy release rate while undergoing stress corrosion cracking (G_{ISCC}). |

5.5 User Submission Checklist

Use the checklist below to confirm all required testing outputs and documentation have been prepared before submission (Figure 2).

| Test Data | | | |
|---------------------------------|--------------------------|--------------------------|--------------------------|
| Sample 1 | | | |
| | RTD | ET | HW |
| <i>Load-Displacement Curve</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Failure Surface Image</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Crack Length Measurement</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample 2 | | | |
| | RTD | ET | HW |
| <i>Load-Displacement Curve</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Failure Surface Image</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Crack Length Measurement</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample 3 | | | |
| | RTD | ET | HW |
| <i>Load-Displacement Curve</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Failure Surface Image</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Crack Length Measurement</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample 4 | | | |
| | RTD | ET | HW |
| <i>Load-Displacement Curve</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Failure Surface Image</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Crack Length Measurement</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Sample 5 | | | |
| | RTD | ET | HW |
| <i>Load-Displacement Curve</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Failure Surface Image</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <i>Crack Length Measurement</i> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Documentation: | | | |
| Entry Form | | <input type="checkbox"/> | |
| Technical Data Sheet | | <input type="checkbox"/> | |
| Safety Data Sheet | | <input type="checkbox"/> | |

Figure 2. User submission checklist.

6. Submitting Your Adhesive

Submitting your adhesive to NMSP is the final step in preparing your product for evaluation. This process ensures all data and documentation meet the platform’s requirements, providing a streamlined pathway toward qualification. Below, we outline steps for submitting, the review criteria, and feedback process you can expect after submission.

6.1 How to Submit

Submit completed data package to usarmy.apg.devcom-arl.list.carc@army.mil.

6.2 Review Criteria

Once your adhesive is submitted, it undergoes a thorough validation process designed to ensure compliance with NMSP requirements. This process evaluates the quality, completeness, and integrity of your data and documentation while maintaining fairness and transparency.

Validation Process Overview

- 1) **Completeness Check:** Reviewers confirm that all required files and metadata have been submitted and formatted correctly.
 - a. Key Items Checked
 - i. Load-displacement curves for all 15 samples across the 3 testing conditions.
 - ii. High-resolution failure surface images that meet resolution standards.
 - iii. Complete and accurate metadata detailing testing and preparation processes.
 - iv. Data integrity.
 - v. Verification of the accuracy and consistency of submitted data, including checks for:
 1. Misaligned or incomplete data points.
 2. Missing crack length measurements or discrepancies between test results and metadata.
- 2) **Adherence to Standards:** Reviewers ensure that all testing methodologies align with ASTM standards or equivalent practices. Submissions using alternate methods must include detailed explanations.
 - a. Focus Areas
 - i. **Consistency Across Tests:** Are the results logically consistent across all conditions?
 - ii. **Metadata Clarity:** Does the metadata provide sufficient detail to replicate testing processes?
 - iii. **Documentation Accuracy:** Are documents, such as the TDS and SDS, complete and aligned with submitted test results?

6.3 Feedback Process

After the review is complete, submitters will receive a communication indicating the results of the validation process. This feedback may include the following:

- **Validation Results:** A summary indicating whether the submission meets NMSP standards or requires additional action.
- **Required Revisions:** Identification of missing or incomplete files, along with specific instructions for corrections.
- **Next Steps:** Guidance on resubmission or, if applicable, advancement to the next stage of qualification.

6.4 Logistics

- **Initial Review Results:** [within 10 business days of submission].
- **Resubmission Window for Corrections:** [30 business days].
- Results will be delivered via email and Platform portal.

7. FAQ and Key Considerations

What happens after I submit my data?

Your submission will go through a thorough review process where reviewers check for completeness, consistency, and adherence to standards. If any issues are identified, you will receive instructions for revisions. The timeline for review and feedback depends on the quality of your submission.

Is my data protected?

All submissions are handled securely, and proprietary data—such as formulations or manufacturing methods—is never shared. Benchmarking tools only display anonymized, aggregated performance data, ensuring confidentiality and data protection.

What information is NOT required for submission?

You do not need to provide proprietary formulations, trade secrets, or sensitive internal details about your adhesive. The platform focuses on performance data and metadata that demonstrate compliance and reliability without compromising confidentiality.

What are common mistakes that lead to delays?

- **Missing or incomplete metadata:** Ensure all details, such as curing times, surface prep, and test parameters, are included.

- Inconsistent data: Align outputs like load-displacement curves and crack length measurements with sample IDs and test conditions.
- Formatting errors: Submit data in the correct formats (CSV for data, JPEG/PNG for images). Ensure files are not corrupted.
- Improper file naming: Follow the naming conventions provided earlier to prevent confusion during the review process.

How can I make the submission process smoother?

- Prepare as you test: Collect metadata and testing outputs simultaneously to avoid errors later.
- Use templates: Use the standardized templates provided by NMSP to ensure proper formatting.
- Conduct a self-audit: Before submitting, verify that all required files are included, correctly labeled, and formatted.

Why is metadata so important?

Metadata ensures the reproducibility and reliability of your results. It is a critical component that enables reviewers to validate your submission and provides transparency for broader industry benchmarks. Details like surface prep methods, curing conditions, and equipment settings are key to successful submissions.

Tips for Success

- Start early: Begin organizing your data and metadata during the testing process.
- Check for completeness: Review your submission to confirm no files, measurements, or details are missing.
- For questions during the process, please contact: usarmy.apg.devcom-arl.list.carc@army.mil.

8. Product Entry Form

PRODUCT ENTRY FORM [walkthrough tabs on travel spread sheet]

The Product Entry Form will collect all relevant details about the adhesive product being submitted. Below is a draft of information needed. Follow the self-explanatory tabs sequentially from left to right, as shown in Figure A-1 in Appendix A.

- 1) **Table of Contents Tab**
 - a. Hyperlinks provided to specific testing sections.
- 2) **Single-Lap Joint (SLJ) Fabrication Tab**

- a. Provide details for fabricating the SLJ coupons.
 - b. Provide a unique sample ID for each individual SLJ coupon.
- 3) SLJ Thickness Tab**
- a. Calculate the bondline thickness for each individual SLJ coupon.
- 4) SLJ Strength Tab**
- a. Calculate the maximum strength and failure displacement for each individual SLJ coupon.
 - b. Provide an assessment of the visual mode-of-failure.
- 5) SLJ Machine Data Tab**
- a. Copy and paste the time, load, and crosshead displacement data for each individual SLJ coupon.
 - b. Use the separate SLJ analysis spreadsheet to correct the load-displacement curves for load-train slack, which is ignored at the front of the curves.
- 6) Double Cantilever Beam (DCB) Fabrication Tab**
- a. Provide details for fabricating the DCB joint coupons used for the crack extension testing.
- 7) DCB Thickness Tab**
- a. Calculates the bondline thickness for each individual DCB joint.
- 8) DCB Environmental Conditioning Tab**
- a. Provide details for maintaining the environmental conditions required for long-term crack extension measurements.
- 9) DCB Crack Length Tab**
- a. Calculates the strain energy release rate for stress corrosion cracking for the DCB joints.
- 10) Additional Tab**
- a. Provide company contact information.
- 11) MRL Tab**
- a. Provide a self-assessment of the manufacturing readiness level of the adhesive product.

9. Potential Future State of the Platform

9.1 Current State: Load-Displacement Curve Modeling and Early Predictive Insights

At present, the platform focuses on extracting insights from load-displacement curves obtained through lap-shear testing. Current platform capabilities are demonstrated in the walk-through video embedded in Appendix B. These curves

serve as a primary tool for quantifying mechanical performance metrics such as peak load capacity, displacement at failure, and energy dissipation.

To identify patterns across material samples, clustering techniques are applied based on the mean absolute error between curve profiles. This approach groups samples with similar mechanical responses, allowing users to isolate trends more effectively. Users can further refine analyses by filtering data based on key factors such as test condition, adhesive type, and adhesive group, enabling more precise comparisons within targeted subsets of material systems.

Following clustering, a range of regression methodologies can be employed to model relationships between material features and mechanical behavior. Techniques such as linear regression, Bayesian inference, and kernel-based regression are used to generate best-fit models that interpolate and predict performance outcomes across new or unseen samples.

This capability establishes an early foundation for predictive material design, providing the ability to derive performance expectations based on observed mechanical trends. It lays the groundwork for future scaling into full structure–property–performance integration as the platform evolves.

9.2 Future State: Microstructural Feature Extraction and Failure Mode Correlation

During the next phase of development, the platform will integrate advanced microstructural feature extraction algorithms to deepen the connection between material structure and performance. Leveraging computer vision image analysis, the platform will automatically identify and quantify critical microstructural features such as grain morphology, phase dispersion, void networks, and defect populations.

These extracted features will be directly correlated with mechanical performance outcomes, specifically failure modes observed during lap-shear testing and their associated load-displacement behaviors. By analyzing patterns in peak loads, crack propagation characteristics, and energy absorption profiles, the Platform will reveal how subtle variations in microstructure influence macroscopic performance.

This capability will operationalize the Materials Science Tetrahedron; linking Processing (manufacturing methods and treatments) to Structure (microstructural features), to Properties (mechanical responses such as toughness, strength, and ductility), to Performance (observed failure behavior in real-world testing).

By systematically bridging these domains, the Platform will enable users to:

- Predict dominant failure modes based on microstructural signatures
- Shorten design cycles by forecasting mechanical outcomes early in development
- Optimize processing parameters to engineer microstructures for targeted performance
- Enhance materials qualification workflows through data-driven structure–property–performance mapping

By advancing beyond data management, the Platform will serve as an active material intelligence system that converts microstructural observations into targeted design and processing insights. This will enable more efficient, cost-effective development of new materials and promote faster innovation throughout the material lifecycle.

10. References

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Appendix A. Walk-through of Self-Submission Data Package

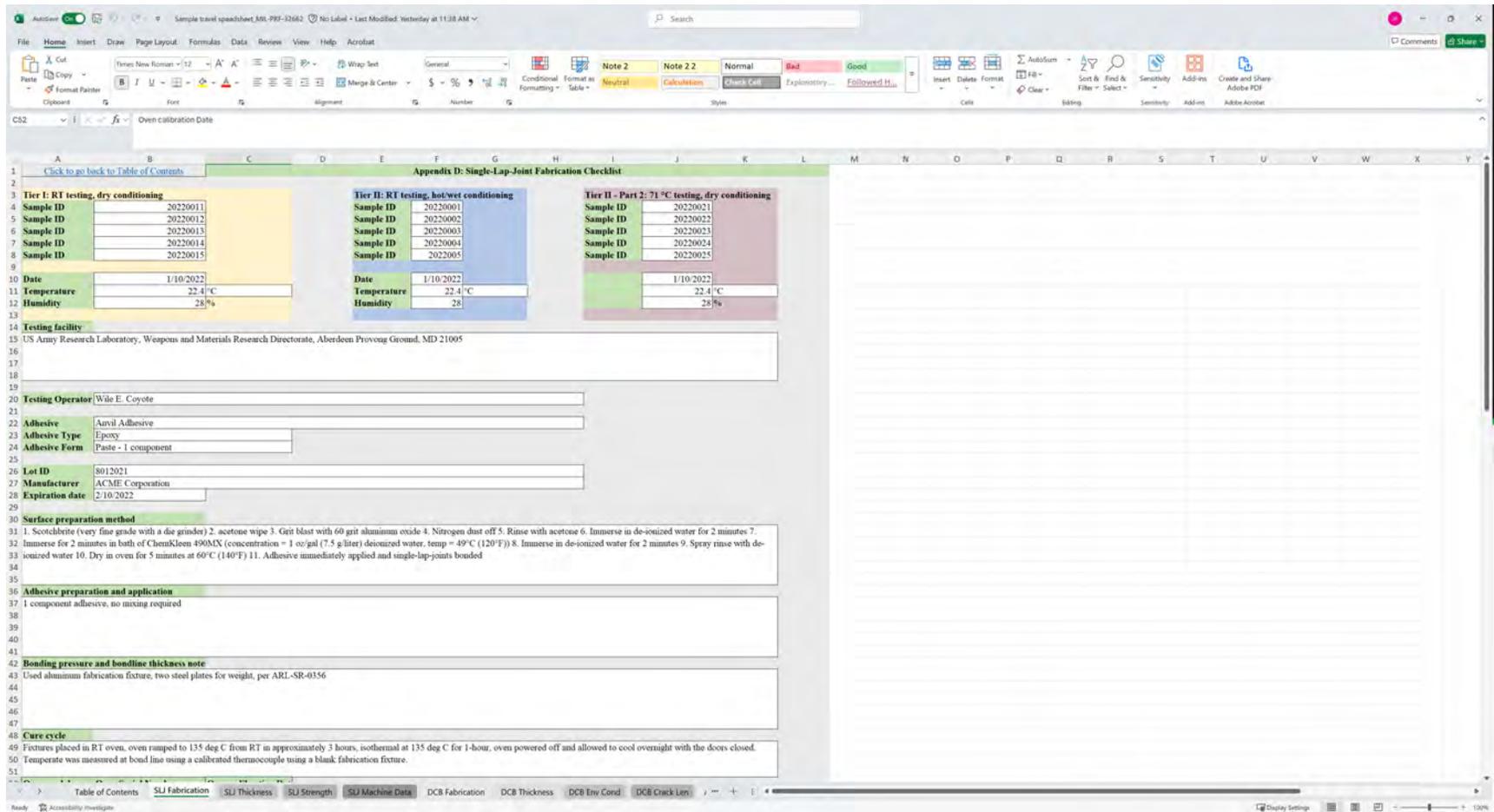


Figure A-1. Two Microsoft Excel-based travel sheet files are included as attachments with this report as templates for data submission, “Sample travel spreadsheet_MIL-PRF-32662.xlsx” and “Blank travel spreadsheet_MIL-PRF-32662.xlsx.” The travel sheet is structured to follow the workflow of MIL-PRF-32662. Use the “Sample” as a reference and complete the “Blank.” Contact usarmy.apg.devcom-arl.list.carc@army.mil for assistance with populating the travel sheets.

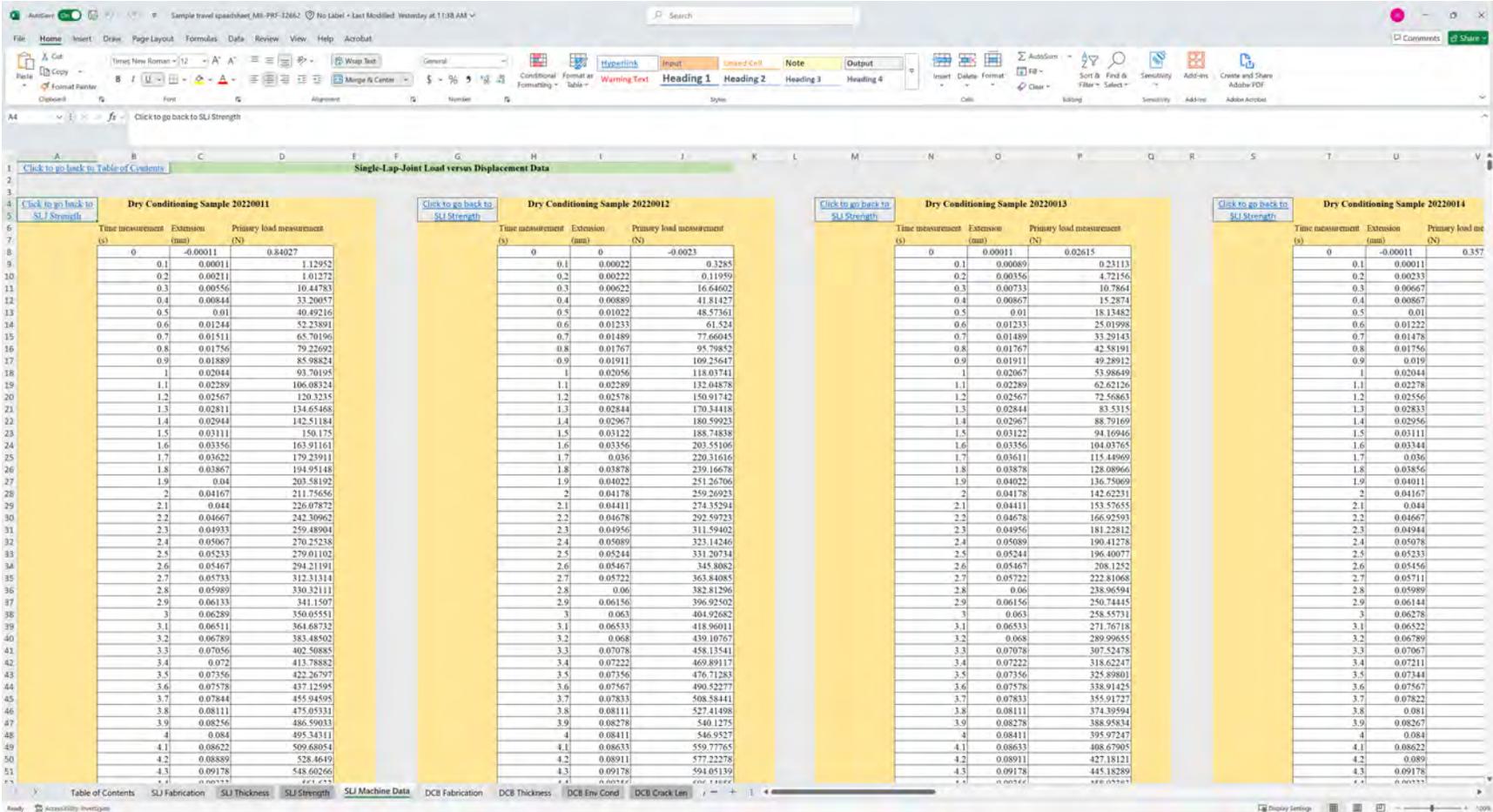


Figure A-2. Use “single lap joint analysis file.xlsx” (shown in Figure A-3) to format the time, extension, and load data captured from the load testing frame. Paste the formatted data into the “SLJ Machine Data” tab on the master travel sheet.

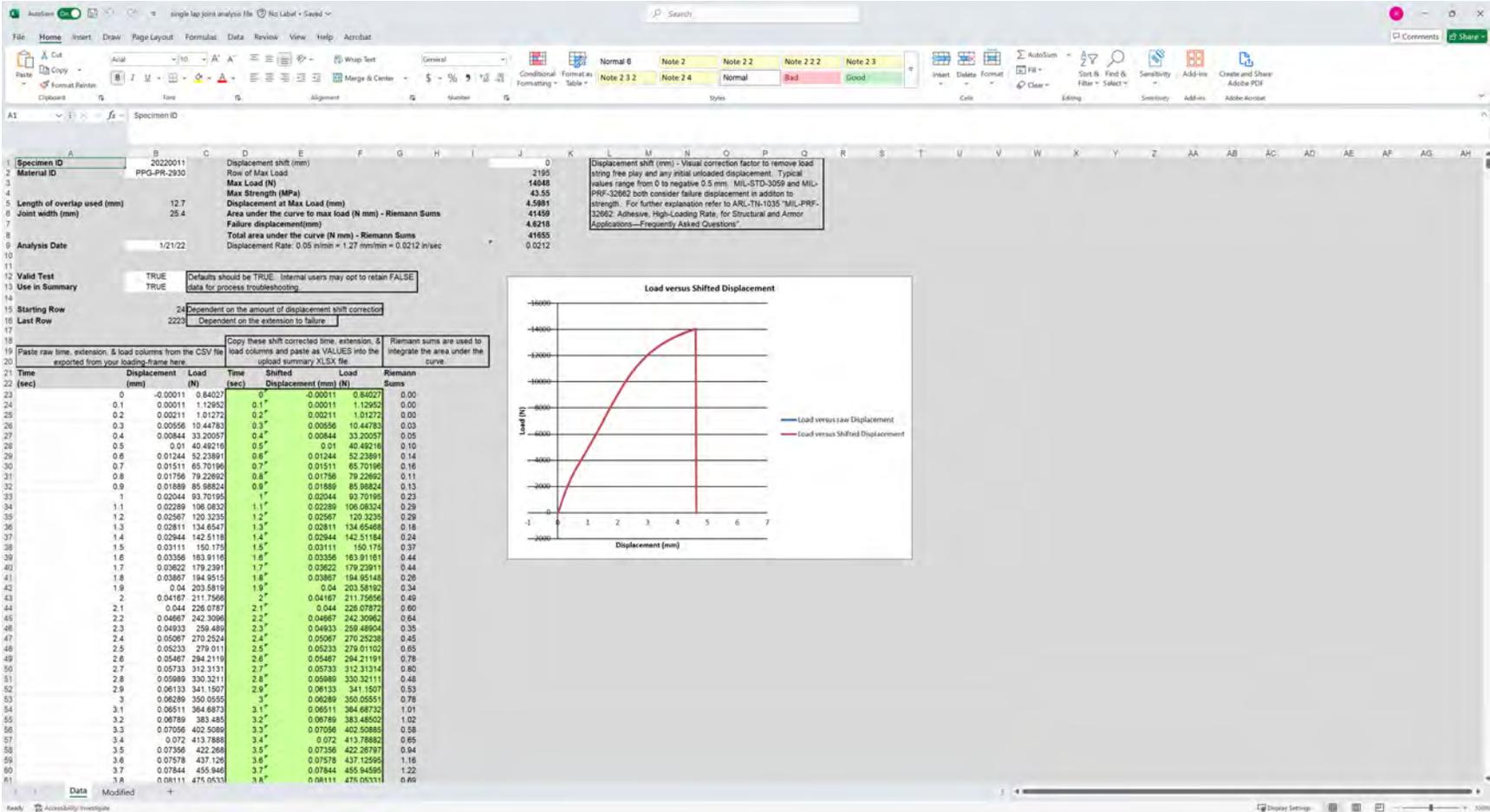


Figure A-3. Use “single lap joint analysis file.xlsx” to format the time, extension, and load data captured from the load testing frame. Paste the formatted data into the “SLJ Machine Data” tab on the master travel sheet (shown in Figure A-2).

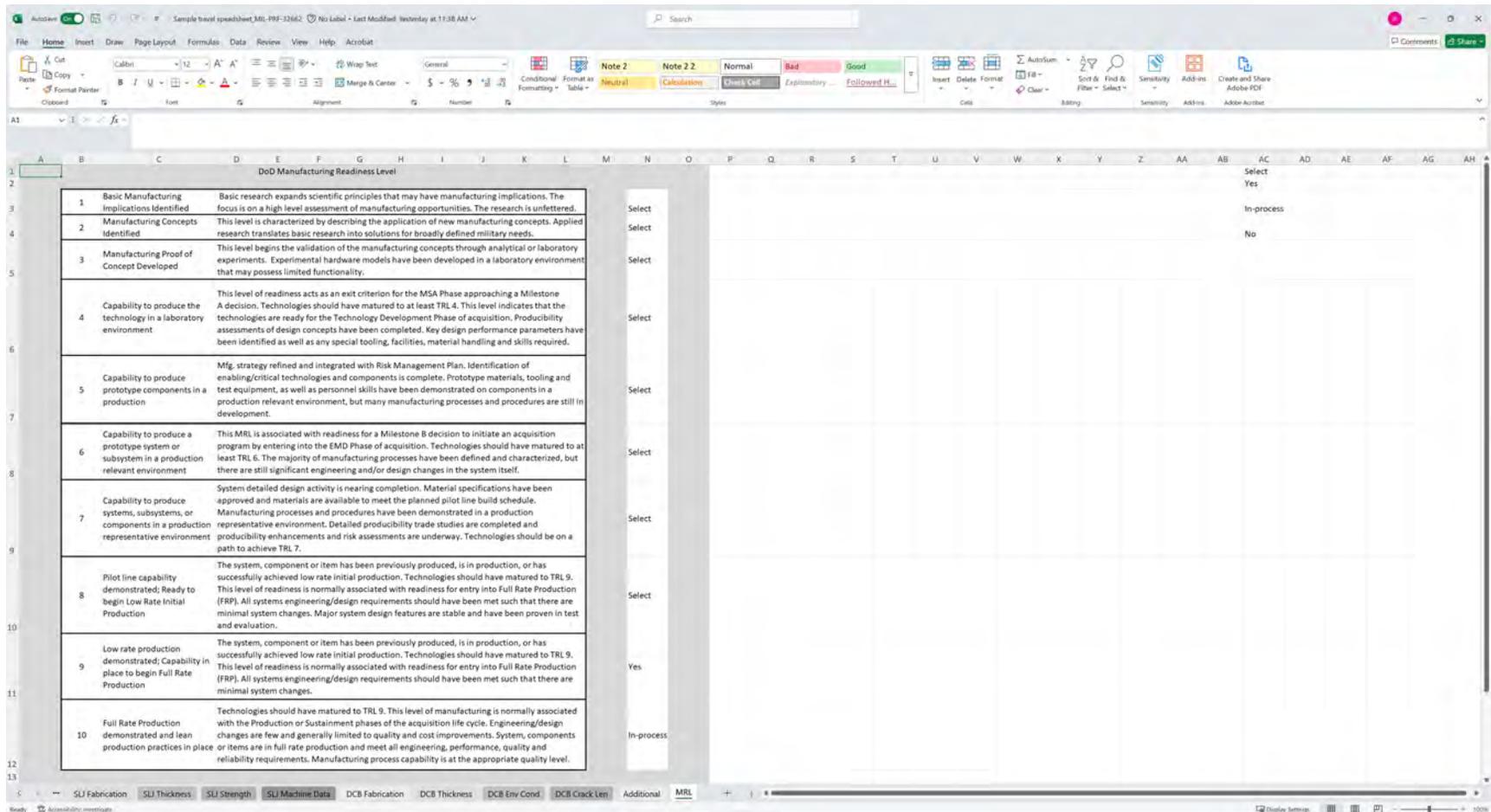


Figure A-4. Select the appropriate Manufacturing Readiness Level (MRL) of the adhesive. MIL-PRF-32662 is an anticipatory standard that deliberately seeks high-risk/high-reward product. An advantage of hosting qualified data on the NextGen Materials Standards Platform (NMSP) is the potential to showcase low MRL experimental adhesives for further potential development in marketing areas beyond direct DoD relevance.

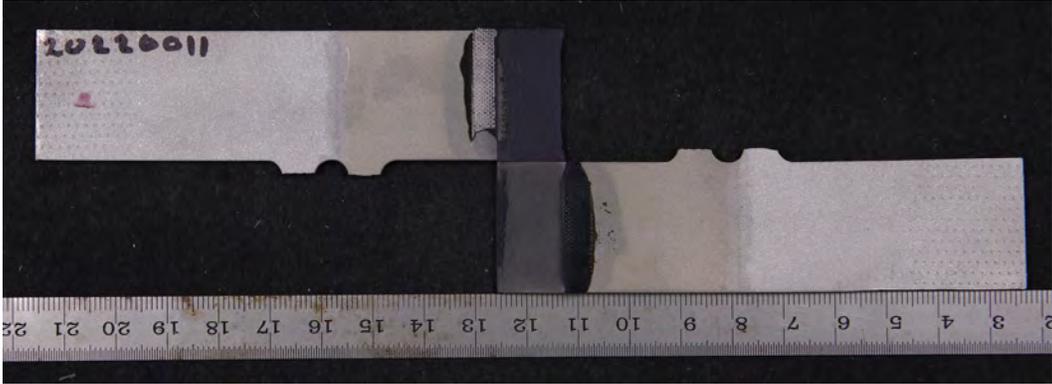


Figure A-5. Include high-resolution images for each of the single-lap-joint individual test specimens that clearly show the visible mode of failure. Include a ruler in the image.

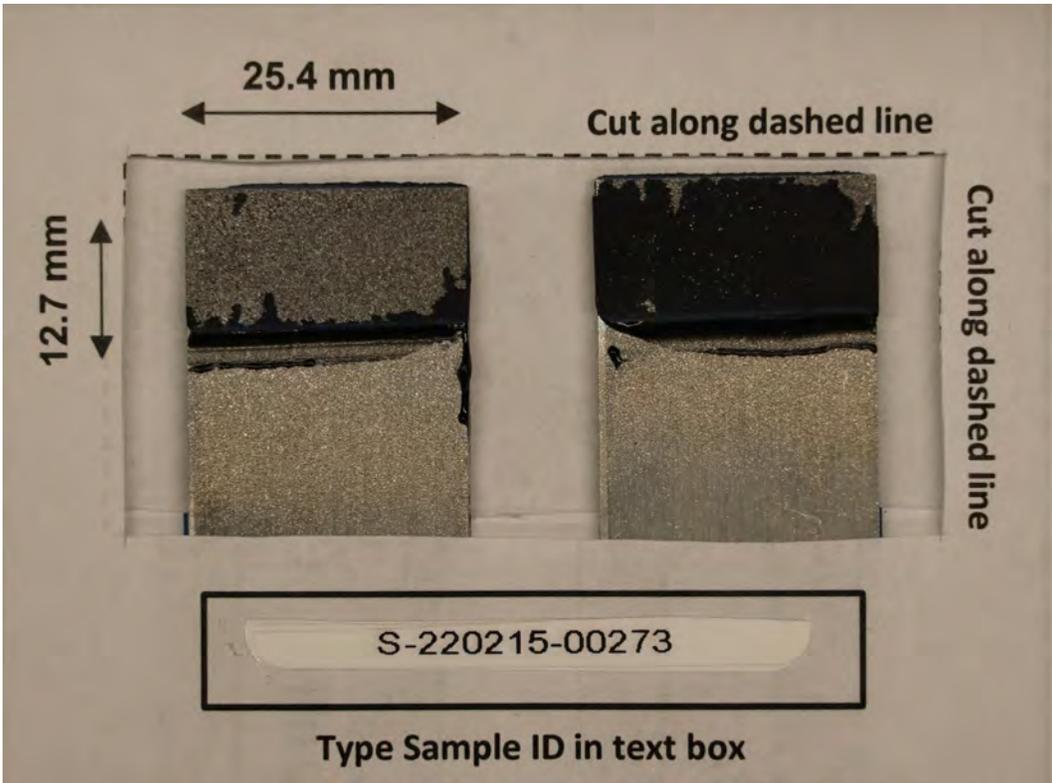


Figure A-6. A printable template is also included in MIL-PRF-32662 that can be used in conjunction with a flatbed scanner to capture mode-of-failure images.

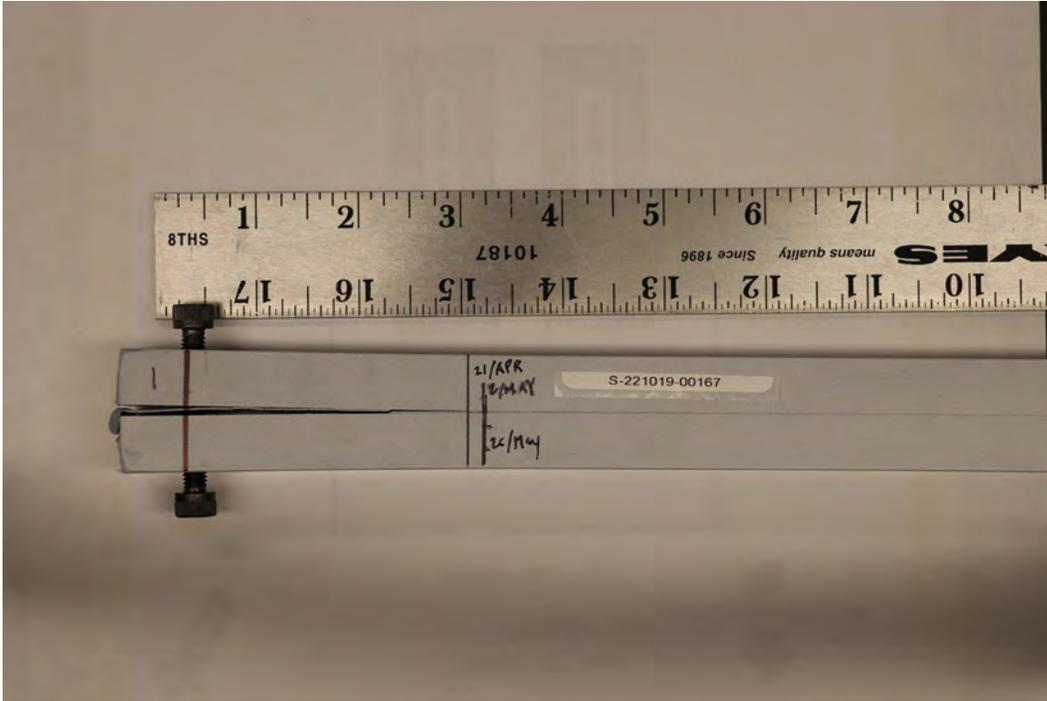
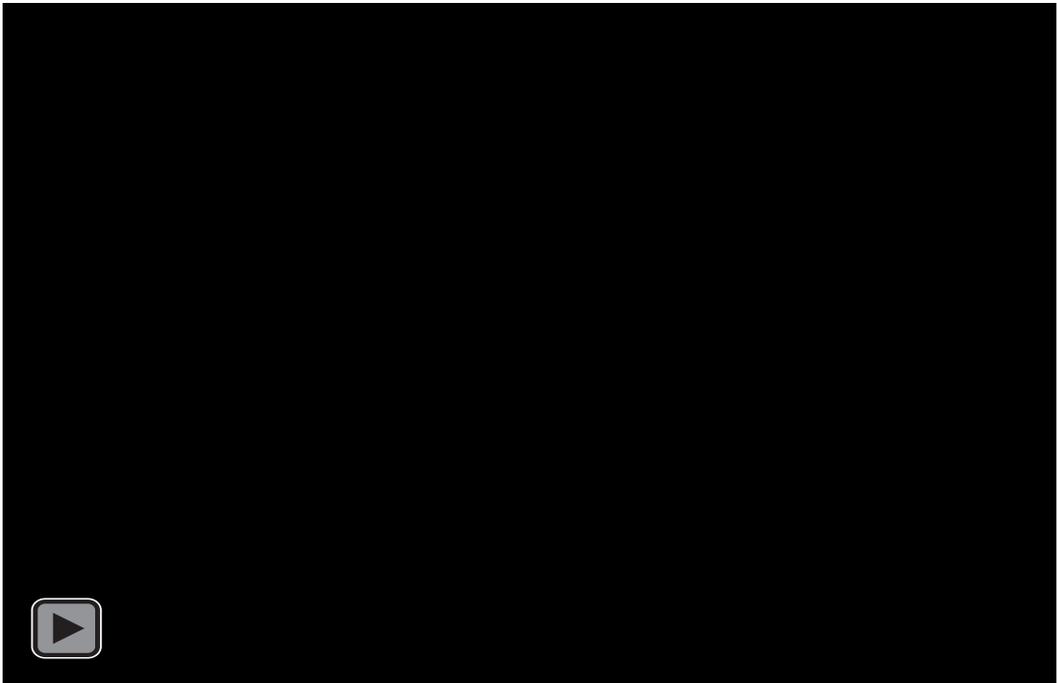


Figure A-7. Include high-resolution images for each of the individual crack extension test specimens that clearly show the crack growth following Tier III testing. Include a ruler in the image.

Appendix B. Video Walk-through of the Platform*

* DISA STIG security settings prohibit embedded video (.mp4) playback from Government Furnished Equipment.



List of Symbols, Abbreviations, and Acronyms

| | |
|----------|---|
| AI | artificial intelligence |
| ARL | Army Research Laboratory |
| ASM | American Society for Metals |
| CAD | computer-aided design |
| CSV | comma-separated value |
| DCB | double cantilever beam |
| DEVCOM | U.S. Army Combat Capabilities Development Command |
| DoD | Department of Defense |
| dpi | dots per inch |
| DTIC | Defense Technical Information Center |
| FAQ | Frequently Asked Questions |
| GVSC | Ground Vehicle Systems Center |
| IAC | Information Analysis Center |
| ID | identification |
| ISG | Industrial Steering Group |
| JPG/JPEG | Joint Photographic Experts Group |
| ML | machine learning |
| MMPDS | Metallic Materials Properties Development and Standardization |
| MRL | Manufacturing Readiness Level |
| NMSP | NextGen Materials Standards Platform |
| PDF | Portable Document Format |
| PNG | Portable Network Graphics |
| R&D | Research and Development |
| SDS | Safety Data Sheet |
| SLJ | single-lap joint |
| STI | Scientific and Technical Information |

| | |
|------|---------------------------------|
| TDS | Technical Data Sheet |
| TIFF | Tag Image File Format |
| WPI | Worcester Polytechnic Institute |

1 DEFENSE TECHNICAL
(PDF) INFORMATION CTR
DTIC OCA

1 DEVCOM ARL
(PDF) FCDD RLB CI
TECH LIB