ENHANCED TYPE VII PLASTIC MEDIA, eStrip™, (MIL-P-85891A) FOR THE MILITARY AEROSPACE

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1. ABSTRACT

This paper will outline the characteristics of **eStrip™** abrasive media products recently qualified as Type VII starch-g-acrylic media. The objectives and results of ADM's efforts to engineer and develop products meeting or exceeding previous Type VII versions will be reviewed. The mechanical effects, performance, and other data generated by ADM and other organizations will be presented and discussed.

2. INTRODUCTION

The objective of this paper is:

A. To present comparative performance data and the resultant mechanical effects of Type II, Type V and Type VII media; and

B. To review a summary of the first article performance characteristics compared to previous Type VII versions.

3. BACKGROUND INFORMATION

In the early 1980s, the US Navy (USN) and US Air Force (USAF) evaluated different types of plastic media for use on airframes and components. The early results were promising and indicated that a substitute for chemical stripping had been found. However, the initial hope of eliminating chemicals was dampened as a result of some early studies. Several organizations found that Type II (urea) plastic media caused undesirable effects on aluminum substrates after blasting (e.g. fatigue life, fatigue-crack growth-rate changes).

The next blast media of significance reviewed by the USN and USAF was designated Type V acrylic. Type V media was found to have less negative effects on aircraft substrates when compared to Type II. Although Type V did not strip as fast as Type II, it produced lower Almen arc heights and lower surface roughness values, indicating less residual stress on aluminum substrates when impacted.

Today, dry stripping with Type V media is still considered the standard "dry stripping process" for removing aerospace coatings from US military aircraft. However, extensive use of this media has highlighted a residue problem that can affect coating adhesion. This residue, which is left on the surface after blasting, can clearly be seen when chemical conversion treatment is applied to a blasted surface. The residue can cause an uneven, blotchy finish when applying conversion coatings, and may cause subsequent premature coating failure. The residue, believed to be polymethylmethacrylate (PMMA), is very tenacious and is typically removed using a strong solvent such as methyl ethyl ketone (MEK).

In the last decade, several plastic media designations have been included in Mil-P-85891A as alternatives to Type V. Most noteworthy was the introduction of starch-g-acrylic media in the mid-1990's, designated as Mil-P-85891A Type VII. The Type VII designation provided a category for starch/acrylic copolymer products that function much like other plastic media products, yet produced lower residual stress/surface effects to the aircraft substrates.

In 2001, ADM introduced **eStrip™ GP** and **GPX** products that have now been qualified as Mil-P-85891A Type VII products. **eStrip™ GP** is similar to the original Type VII version but does offer improved strip rates and lower consumption rates. **eStrip™ GPX** is an enhanced Type VII media, also offering better strip rates and lower consumption rates, as well moisture resistance versus the original Type VII version.

4. COMPARATIVE PERFORMANCE OF TYPE II, TYPE V AND TYPE VII MEDIA

To determine the relative differences between the three media types, the parameters and guidelines outlined in MIL-P-85891 table III were used. The only significant variations were:

- Use of a **0.375-inch** diameter nozzle (instead of 0.250-inch).
- Proportionally increased flow rate for all three media types to accommodate larger caliber nozzle.

A. Test Panel Description

24-inch x 24-inch panels were prepared in accordance with Mil Spec standards. The panels were 2024 – T3 aluminum, 0.032-inch thick. After chemical conversion treatment, the panels were coated with a polyamide epoxy primer (Mil-P-23377) and a polyurethane topcoat (Mil-C-85286). The panels were prepared by three different aerospace organizations. Coating thickness and pencil hardness results are described in Annex A. Test panels are identified by the color codes: green, gray and blue.

B. Strip Rates

Using parameters outlined in Table III of Mil-P-85891A, the strip rates of the three media types - Type II, Type V and Type VII (**GPX**) - were compared. The results are shown in Table 1 below.

The stand off distance used was 10 inches and the blast angle was 60 to 80 degrees for all media types. For Type V and VII a nozzle pressure of 30 psi was used; while for Type II a lower nozzle pressure of 25 psi was applied. The strip rate is expressed in square feet per minute. The strip rates are an average of three strip tests per media per panel.

Table 1. Comparison of Strip Rates (ft^2/minute)

Panel Type	Green	Gray	Blue	Average
Type II	1.16	0.77	0.96	**0.96**
Type V	0.92	0.61	0.84	**0.79**
Type VII	0.83	0.49	0.72	**0.68**

C. Surface Roughness

Six surface roughness scans of each surface were performed for the different media types using a Mitutoyo MST 301 profilometer. Note that the test panels were clad aluminum. The average R_a values (μ-inches) were obtained after one strip cycle as shown in Table 2.

Table 2. Comparison of Surface Roughness (μ-inches)

Panel Type	Green	Gray	Blue
Type II	333	330	325
Type V	239	207	212
Type VII	158	130	149

D. Almen Arc Heights

To determine the relative amount of residual stress induced by each media type, a set of 8 Aero Almen strips, 2024 T-3 Aluminum (0.032-inch) were blasted for a period of time equivalent to 1 blast cycle and 4 blast cycles. The value reported indicates the deflection (ΔH in inches) of the Almen specimens after being blasted. A higher deflection, or arcing, of the specimens indicates a higher compressive residual stress has been induced. Table 3 presents the average values obtained for each media type and Annex C presents the raw data and the corresponding graph, which summarizes the data.

Table 3. Comparison of Almen Arc Height Results (inches)

Media Type	1X Blast Cycle	4X Blast Cycles
Type II	0.0150	0.0192
Type V	0.0079	0.0094
Type VII	0.0033	0.0044

All impact blasting methods will induce residual stresses. In the impact blasting process, as the media reaches the metal substrate surface, the surface will be mechanically deformed to a certain depth. This deformation, which takes place upon impact, consists of compressing the surface beyond the tensile yield limit of the metal. Immediately after impact, the contracted region that was deformed and yielded plastically under tension recovers only partially; leaving behind a permanent compressive (residual) stressed region (see Fig.1). Early work has shown that coating removal processes that generate more than 0.006-inch deflection or arc height (on 0.032-inch bare aluminum Almen specimens), can negatively affect the mechanical properties of thin aluminum alloys. Consequently, civil aircraft manufacturers will only accept very low arc heights from a given impact process. Thus, due to residual stress concerns, the majority of civil aircraft manufacturers are reluctant to approve Type V acrylic media.

E. Summary of First Article Performance Characteristics

First article testing of **GP** and **GPX** was performed for ADM by Southwest Research Institute (MIL-P-85891A Qualification, starch-g-acrylic media (Type VII), SwRI Project No. 04509 Oct 19 2001)

The five main performance characteristics of a media Type were tested:

- Paint Stripping Rate
- Aggressiveness
- Product Consumption
- Surface Residue
- Anti Static Behavior

The results of the SwRI tests showed that, compared to the previous versions' acceptance criteria of media Type (MIL-P-85891A amendment 2, 26 June 1998), **GP** and **GPX** media performance was equal or superior in all categories.

F. Residue Tests for Type V and Type VII Media

MIL-P-85891 Sec. 3.5.1 states that all plastic blast media will not produce a surface residue that interferes with the application of Mil-C-81706 aluminum chromate conversion coating. The sole exception is Type V acrylic, where MIL-P-85891 allows methyl ethyl ketone (MEK), a volatile solvent, to be used to remove any surface residue.

The ability to use MEK in aircraft overhaul environments is becoming much more onerous. Many locations are now prohibited from using MEK which complicates the problem of removing Type V surface residues.

MIL-P-85891 outlines a test procedure to determine the presence of an interfering residue caused by blasting media. After initial cleaning, one half of a 2024 T-3 bare aluminum panel is covered with a similar panel. The exposed side of the test panel is blasted for 60 seconds using the same parameters used to determine the performance characteristics (as outlined in the Mil-P-85891 specification). After blasting, the panels are rinsed with de-ionized water and wiped dry with cheesecloth. After drying, the test panels are immersed in a chromate conversion coating solution for 3 minutes. The blasted side of the test panel is compared to the masked (un-blasted) side of the panel. A significant difference in color or non-uniformity of the Alodine coating on the blasted portion of the panel indicates an interfering residue. The appearance of the conversion coating when a Type V residue is present is shown in photos 1 and 2.

ADM and an independent test organization have conducted the above test using **GP** and **GPX** media. When blasted with **GP** and **GPX** media, no evidence of a residue could be found. To ensure that the visual tests were accurate, supplementary tests were conducted by an outside test agency using a Fourier Transform Infrared (FTIR) spectroscopy method. The results of these tests indicated no chemical residue, or more specifically, no PMMA residue was found on the **GP** and **GPX** blasted panels. When Using Type VII media, normal aircraft detergent and water is sufficient to clean the surfaces before painting.

5. DISCUSSION

Type V plastic media has been considered a dry stripping standard within the US military coating removal arena for some time. The Almen arc height data shown in this study clearly supports the shift from Type II to Type V as being prudent. Priorities for protecting substrate integrity and preserving aircraft life cycles were met while still providing satisfactory stripping performance and meeting production requirements.

However, Type V blast media faces many limitations as new coatings and structural materials have found their way onto military aircraft in the last decade. One primary concern is the ability to deal with a wide cross-section of composite materials that are being used on advanced aircraft, particularly the newer stealth versions. The less aggressive **GPX** Type VII media has already proved viable on many composite systems for several military organizations in North America and Europe. A prime example is the Gripen fighter program in Sweden. Military researchers have found Type VII to be an effective product on surfaces such has carbon fiber, fiberglass, and in some cases Kevlar (see photos 3 and 4). Type VII is dealing with a key issue today: the ability to effectively strip both aluminum and advanced composite materials with one media product.

Another problem area for most plastic media designations is the removal of elastomeric coatings and radar absorbing materials. The impact mechanics of most plastic media do not allow them to efficiently cut such rubber-like coatings. On the other hand, Type VII media has proven effective in removing specialized coatings such has fluoroelastomer and fluoropolymer versions (sealants, thick rubbery coatings and appliqués) as well as RAM coatings (see photos 5 and 6).

The recent approval of ADM's **GP** and **GPX** Type VII media offers military coating removal facilities the opportunity to further improve aircraft substrate integrity while expanding performance on advanced materials such as composites and specialized coatings. Type VII media offers the additional advantage over Type V of not producing a surface residue, thus eliminating the need for MEK solvent (used in the current production environment to remove Type V residue).

6. CONCLUSIONS

ADM's new **GPX** Type VII media holds several distinct advantages over Type V and other Mil-P-85891A plastic media designations.

Type VII media:

- Imparts lower residual stress to aluminum, better preserving aircraft substrate integrity;
- Does not leave a surface residue, eliminating the need for an MEK solvent wipe;
- Can effectively strip both aluminum and composites substrates (i.e. one media/one process for various substrates); and
- Can remove specialized coatings (e.g. radar-absorbing materials) where other plastic media types fail.

These advantages do not come with any significant compromise. Type VII media is used in standard PMB blast systems, and thus no costs for new equipment or modifications are required. Type VII **GPX** is moisture resistant and will react similarly to Type V media if exposed to moisture or high humidity.

ANNEX A

Coating Properties of Test Panels

1. Coating thickness was measured with an eddy current, coating thickness instrument (Elcometer).

2. Coating hardness was determined using a Wolf Wilborne pencil hardness kit.

	Coating thickness	Coating hardness
Green	3.0- 3.6 mils	4H
Gray	2.7- 3.1 mils	6H
Blue	2.9 –3-4 mils	5H

ANNEX B

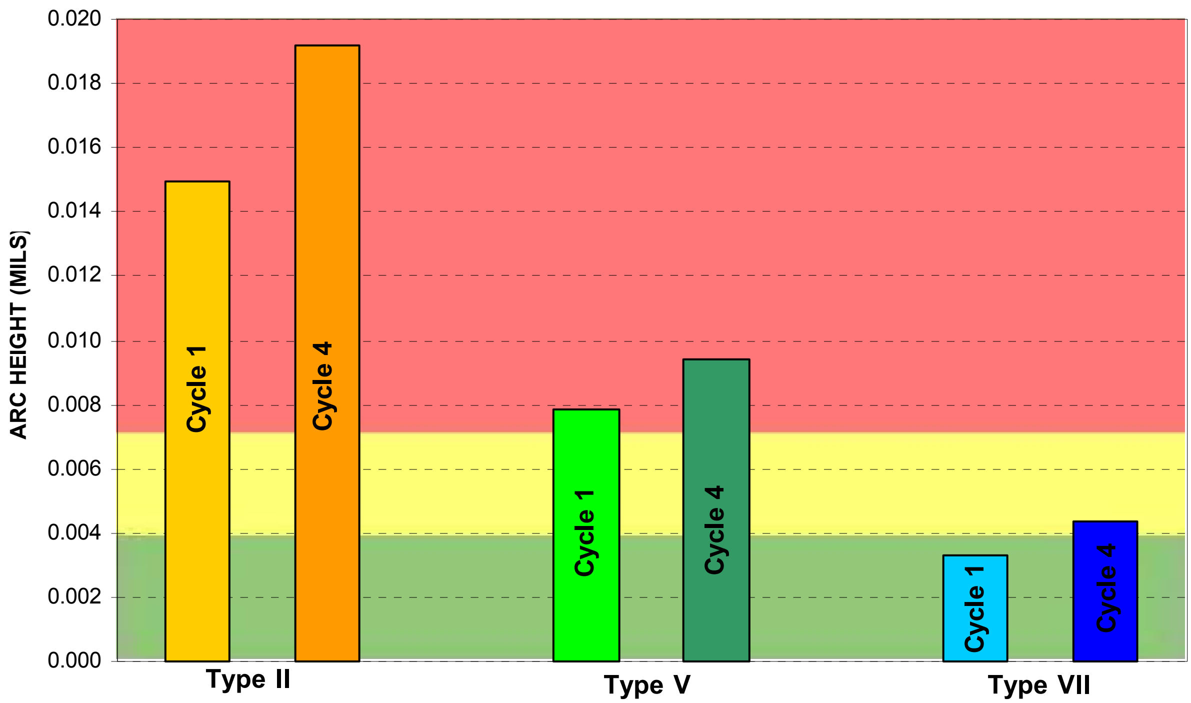
Surface Roughness Data

Green Panels							***Avg.***
Type II	346	334	322	299	345	351	**333**
Type V	250	269	198	225	270	221	**239**
Type VII	201	154	137	133	170	158	**158**
Gray panels							
Type II	351	321	302	347	350	309	**330**
Type V	160	195	231	214	237	207	**207**
Type VII	143	119	127	145	133	116	**130**
Blue panels							**Avg.**
Type II	316	327	355	308	317	329	**325**
Type V	205	193	195	214	233	234	**212**
Type VII	164	143	143	147	153	147	**149**

ANNEX C

Raw Almen Arc Height Data

TYPE II									**Avg.**
1 Blast Cycle	0.0131	0.0154	0.0140	0.0138	0.0150	0.0154	0.0163	0.0166	**0.0150**
4 Blast Cycles	0.0172	0.0190	0.0182	0.0177	0.0208	0.0211	0.0203	0.0194	**0.0192**
TYPE V									
1 Blast Cycle	0.0069	0.0077	0.0075	0.0082	0.0083	0.0085	0.0079	0.0080	**0.0079**
4 Blast Cycles	0.0092	0.0103	0.0094	0.0090	0.0094	0.0098	0.0092	0.0089	**0.0094**
TYPE VII									
I Blast Cycles	0.0033	0.0034	0.0033	0.0032	0.0033	0.0031	0.0034	0.0034	**0.0033**
4 Blast Cycles	0.0040	0.0044	0.0046	0.0046	0.0045	0.0042	0.0043	0.0045	**0.0044**



Graph 1. Residual Stress Induced by Each Type

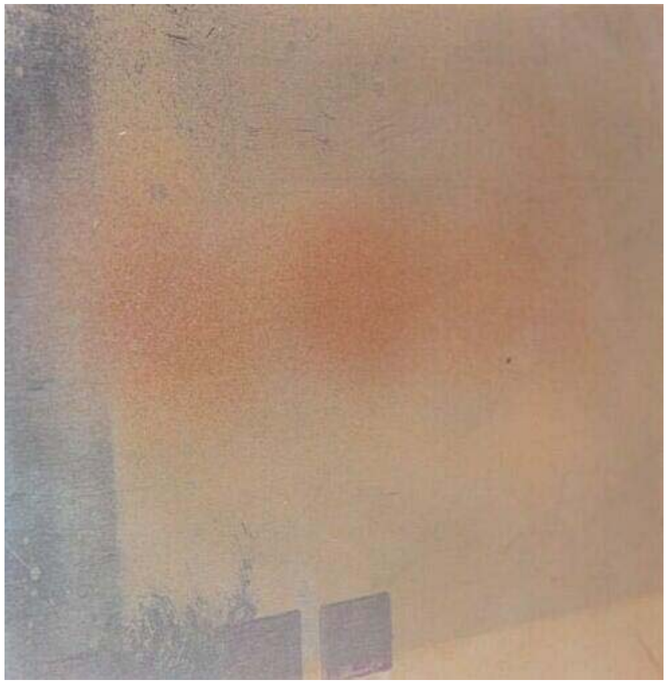


Photo 1: Non-uniform appearance of Type V blasted panel where surface residue has interfered with the application of chromate conversion coating.

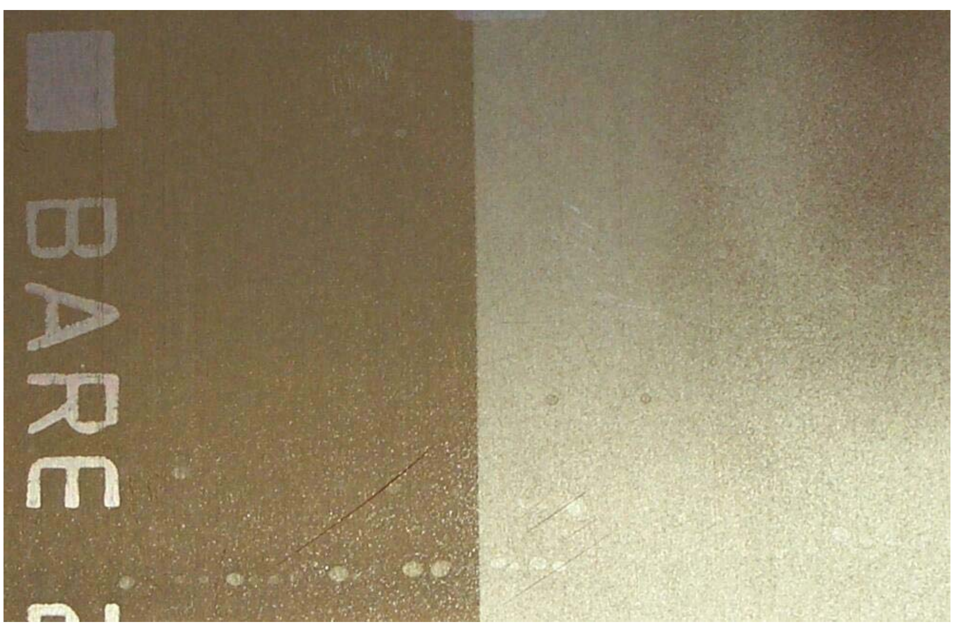


Photo 2: The panel was blasted with Type V media for 60 sec. on the right hand side, the left hand side was not blasted, note the differences after chemical conversion treatment.

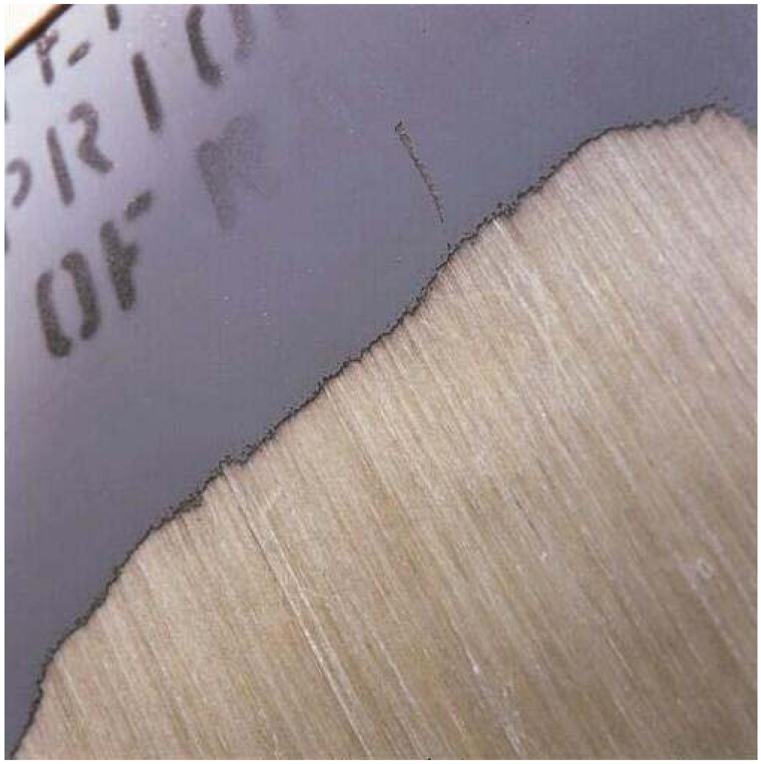


Photo 3: Monolithic wound fiberglass radome stripped to bare substrate without fiber damage.

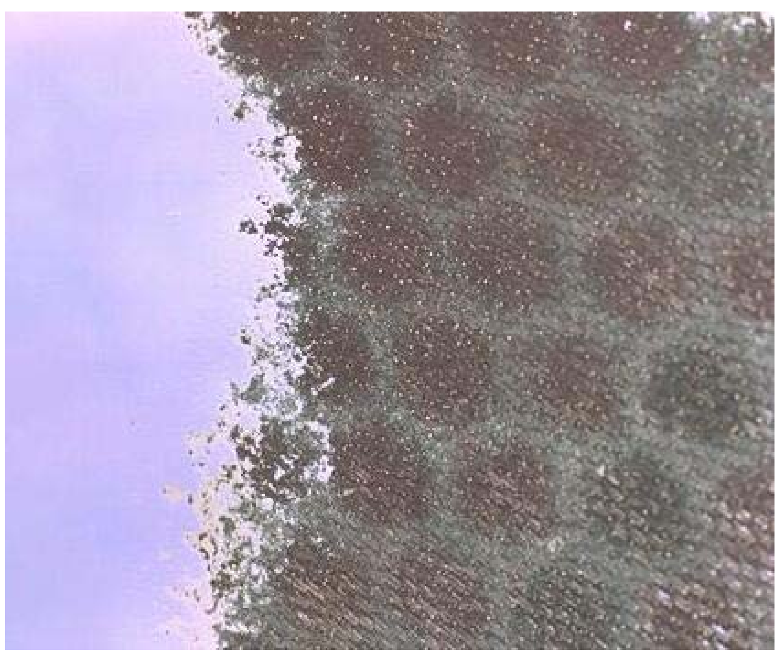


Photo 4: Delicate carbon fiber composite radome, depainted using GPX.

Photo 5: Fluoropolymer coating on carbon fibre substrate removed by GPX.

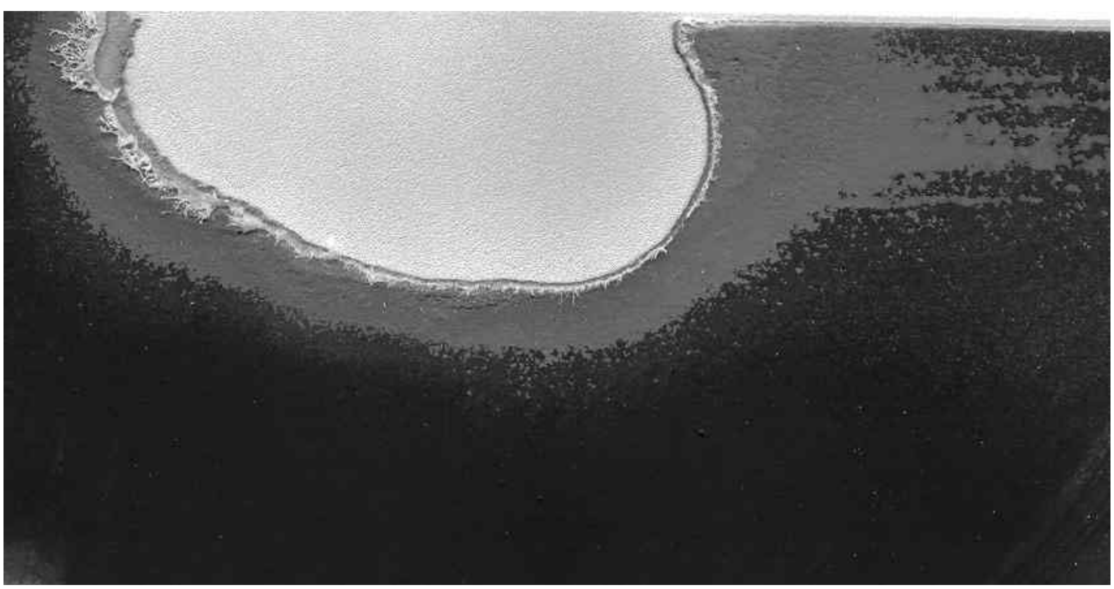


Photo 6: Thick Fluroelastomer military coating removed using GPX.

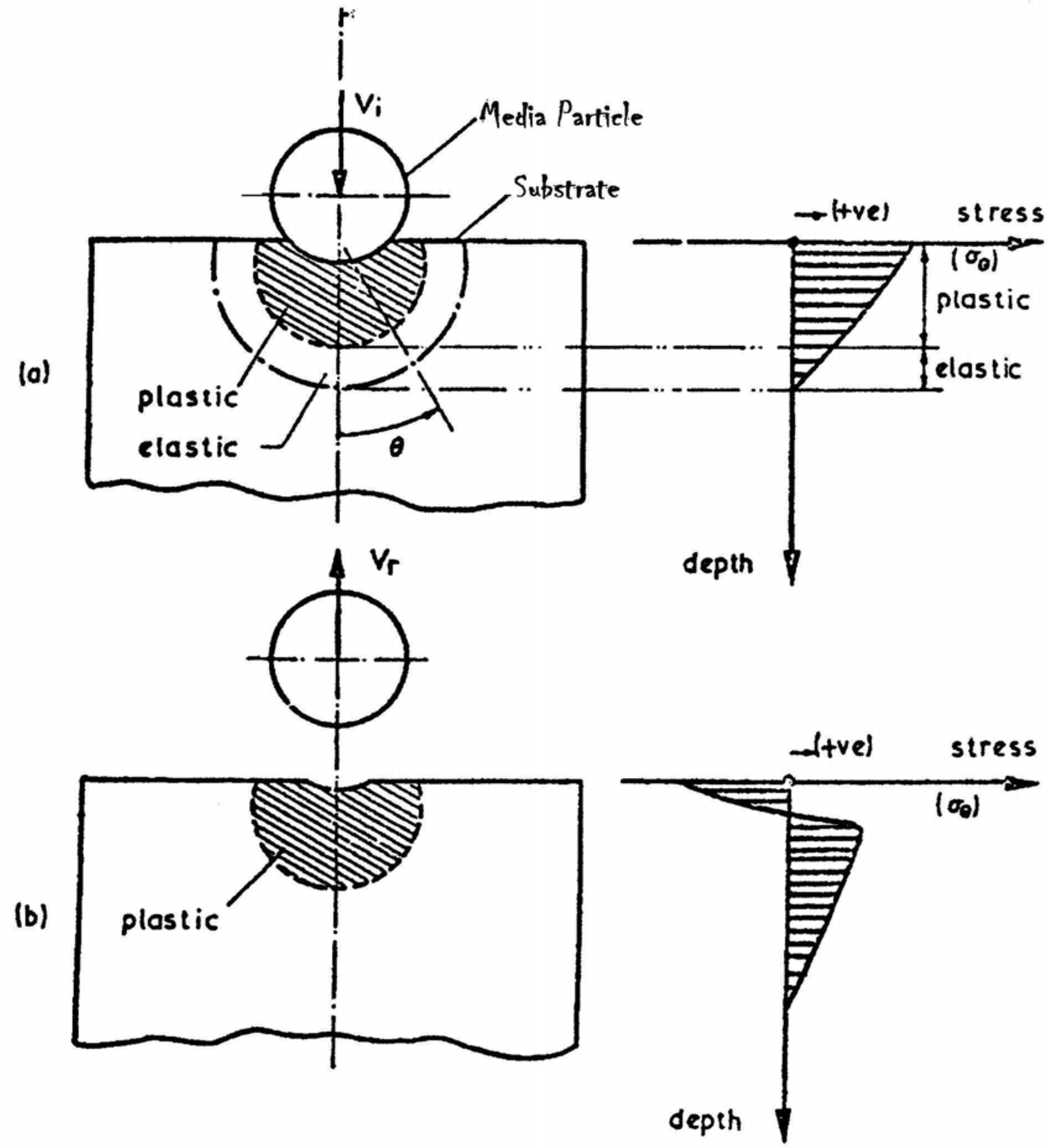


Fig. 1 Suggested Stress Distribution at $\theta = 0^\circ$
(a) Stress Distribution at impact
(b) Residual Stress Distribution

Figure 1. Suggested Stress Distribution