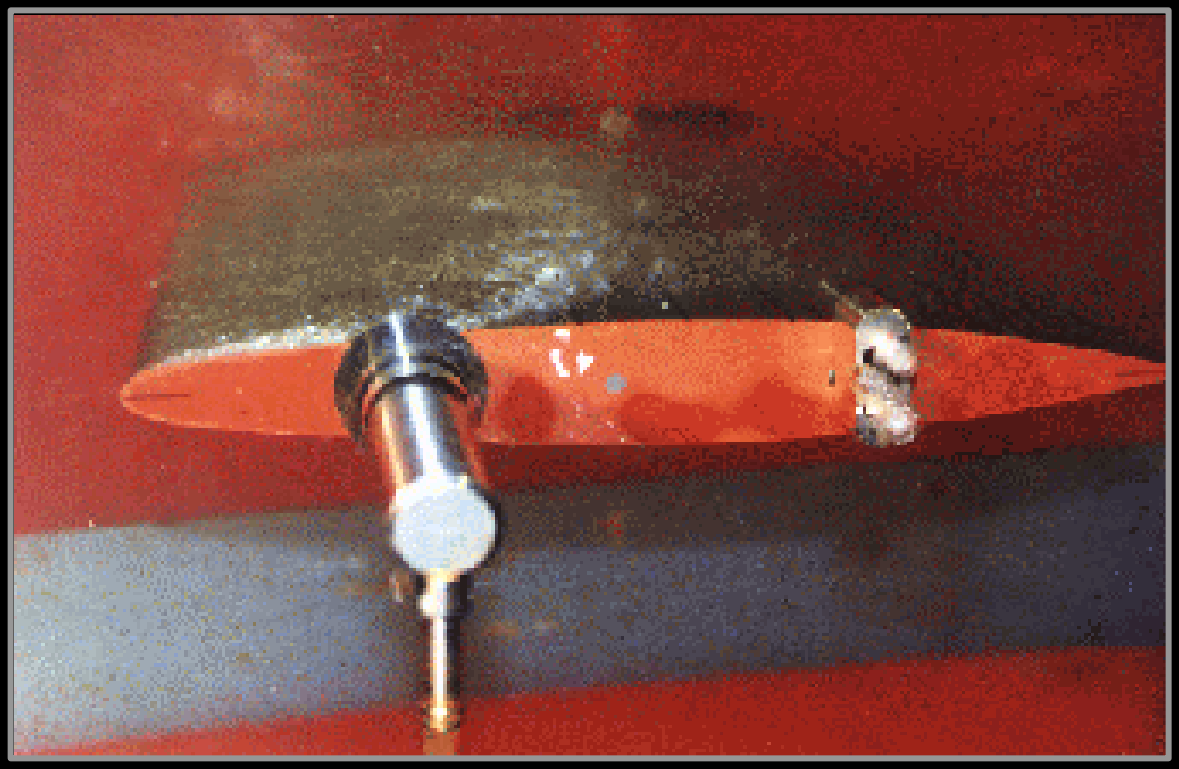
WHAT'S NEW IN THE FIGHT AGAINST CAVITATION

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CAVITATION:

THE RAPID FORMATION AND COLLAPSE OF VAPOR POCKETS IN A FLOWING LIQUID IN REGIONS OF LOW PRESSURE

KINDS OF CAVITATION



Here we see a hydrofoil exhibiting partial cavitation. A hydrofoil is a "lifting" surface. It is like an airplane wing in that it provides lift when a fluid flows past it. Both an airfoil and a hydrofoil create lift by creating a low pressure on the upper surface. In the case of the hydrofoil though, the pressure can become so low that the liquid water transforms into a gaseous water (cavity) The study of cavitating hydrofoils is important for research in the propulsor industry because a propeller is nothing more than a few hydrofoils "wrapped around" a hub.

KINDS OF CAVITATION



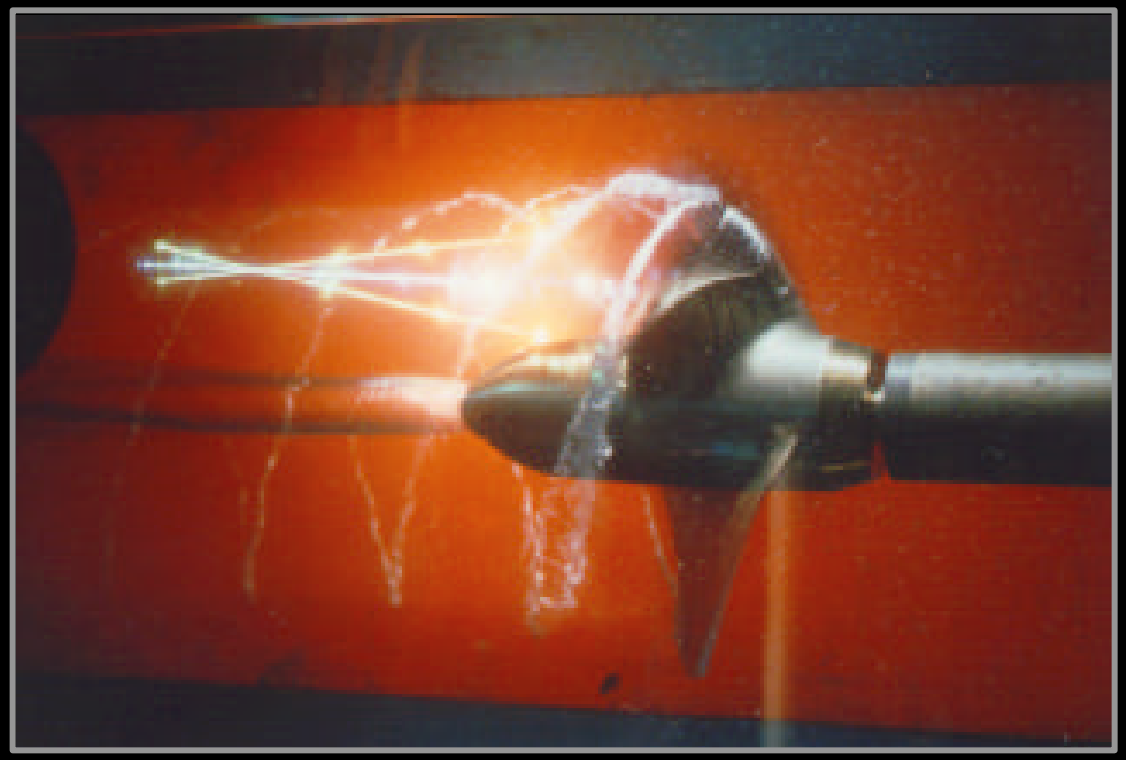
This foil exhibits a fairly clean "sheet" cavity. Although near the end of the cavity, you may notice some "bubble" cavitation. Notice that the cavity does not begin at the leading edge of the foil. (The leading edge is the very front of the foil.) Efforts are underway to correctly model cavitating propellers with non leading edge detachment.

KINDS OF CAVITATION



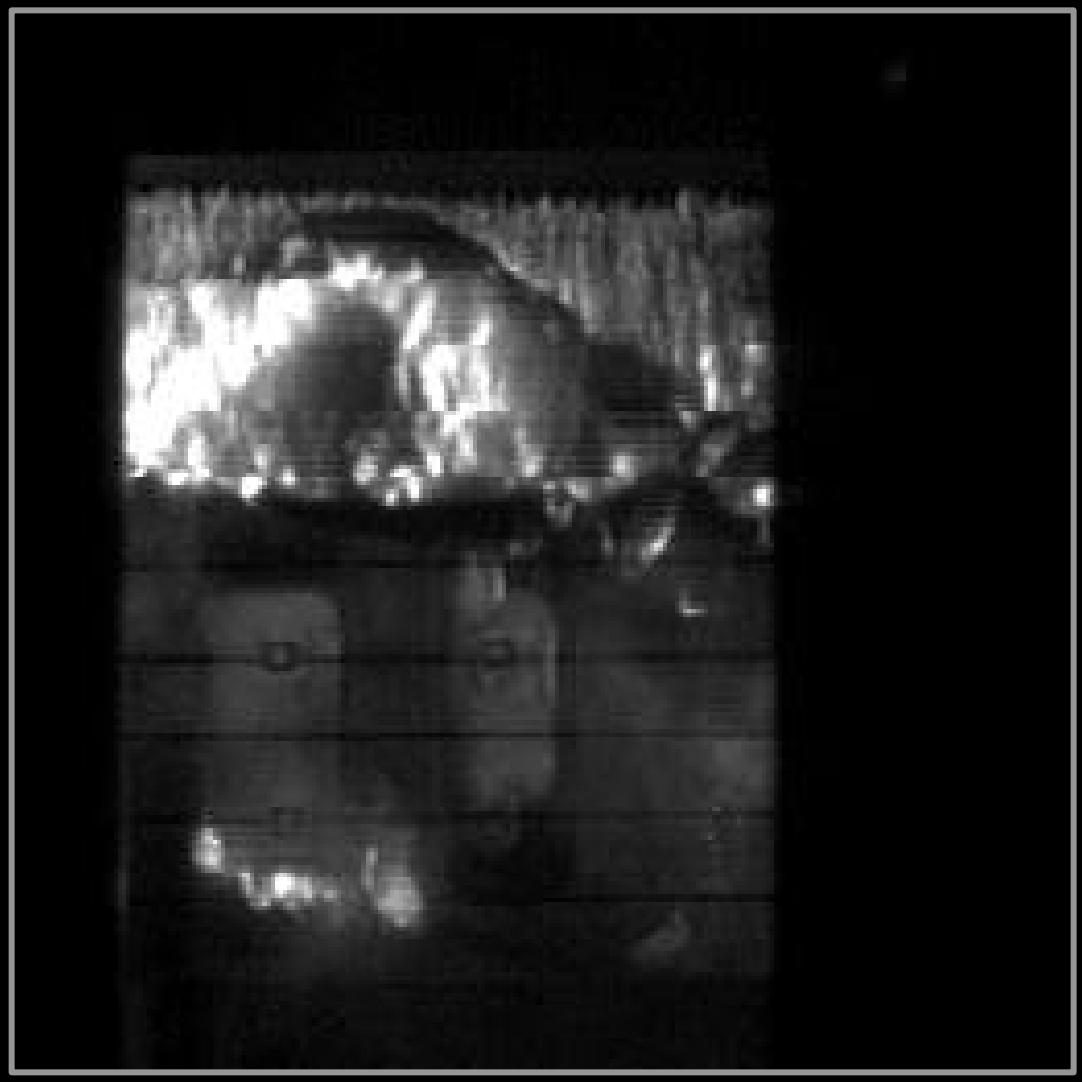
This hydrofoil exhibits "cloud cavitation" Cloud cavities present modeling difficulties because they tend to be unstable. It is also difficult to hydrodynamically model the flow around a "cloud".

KINDS OF CAVITATION



This photograph shows a cavitating propeller. You can clearly see the tip-vortex cavities. Also present is a "hub-vortex" cavity originating from the tip of the hub of the propeller. Research on these forms of cavitation is underway.





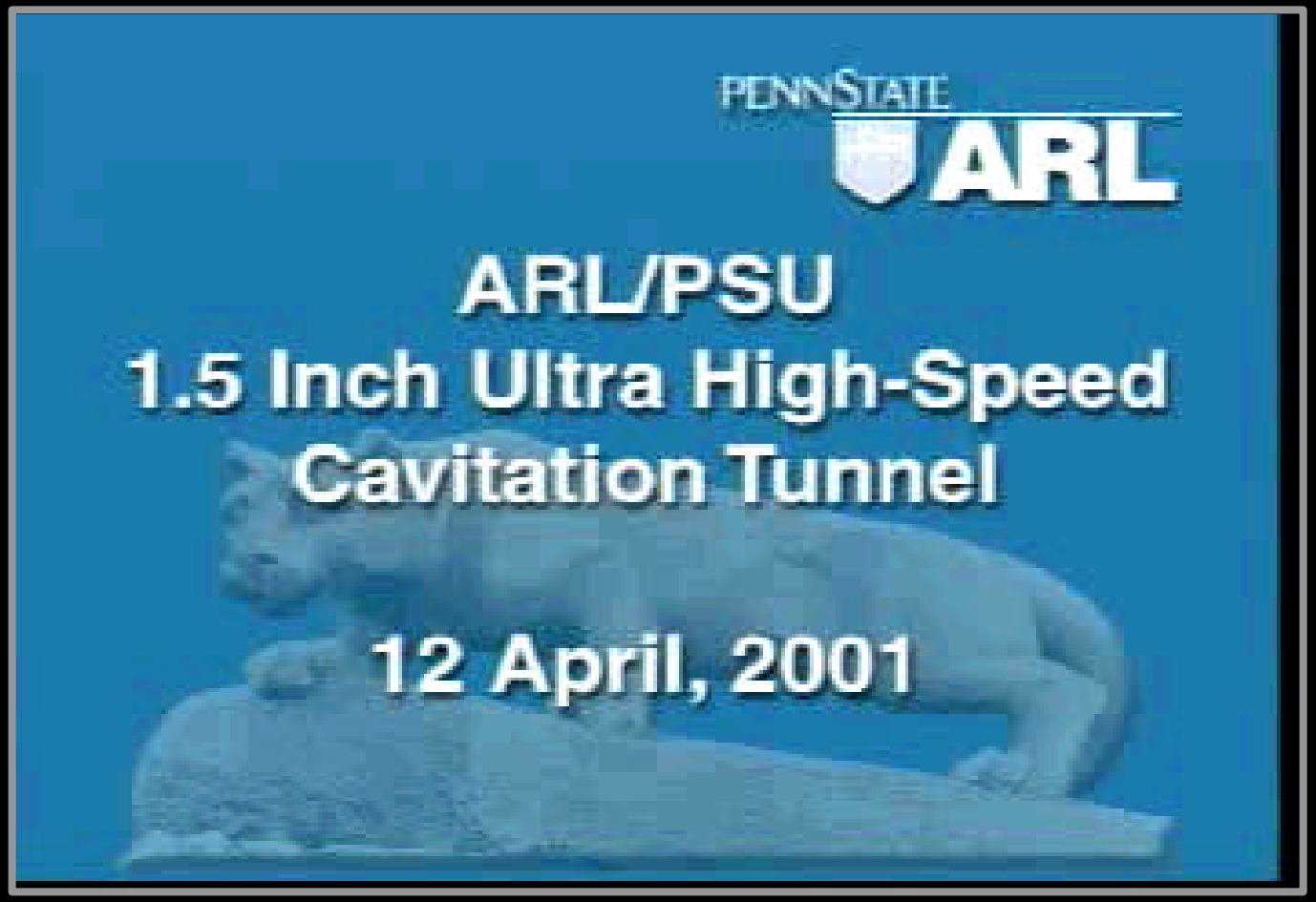




AT THIS TIME I WOULD LIKE TO INTRODUCE

BELZONA 2141 CAVITATION RESISTANT ELASTOMER

THE APPLIED RESEARCH LAB
at PENN STATE



HIGH SPEED CAVITATION TUNNEL

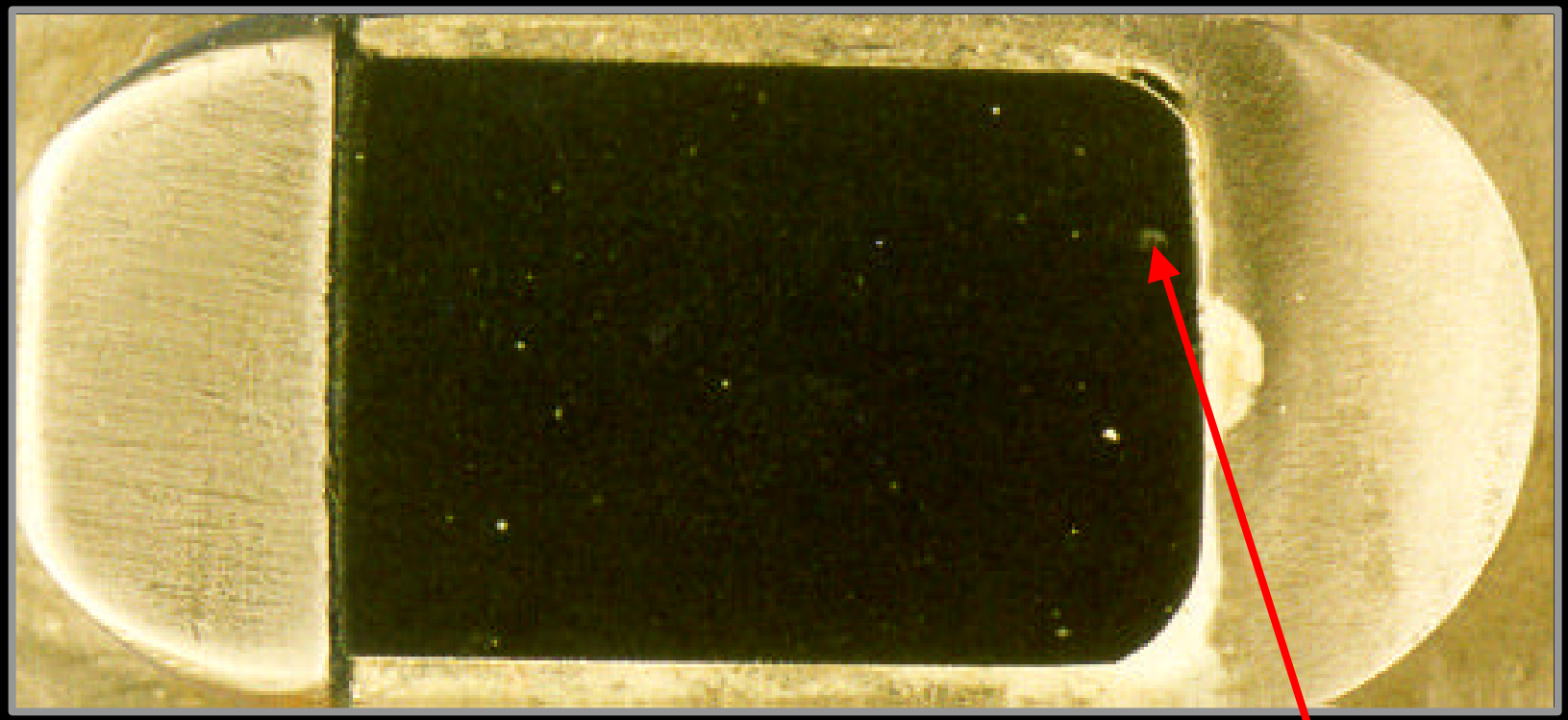
Here are the pictures of the first sample. As you can see there was a surface flaw that was present on the sample. It appears that this flaw was slightly opened during testing. I will send pictures of the other sample soon.

Regards,

Dan Metrey

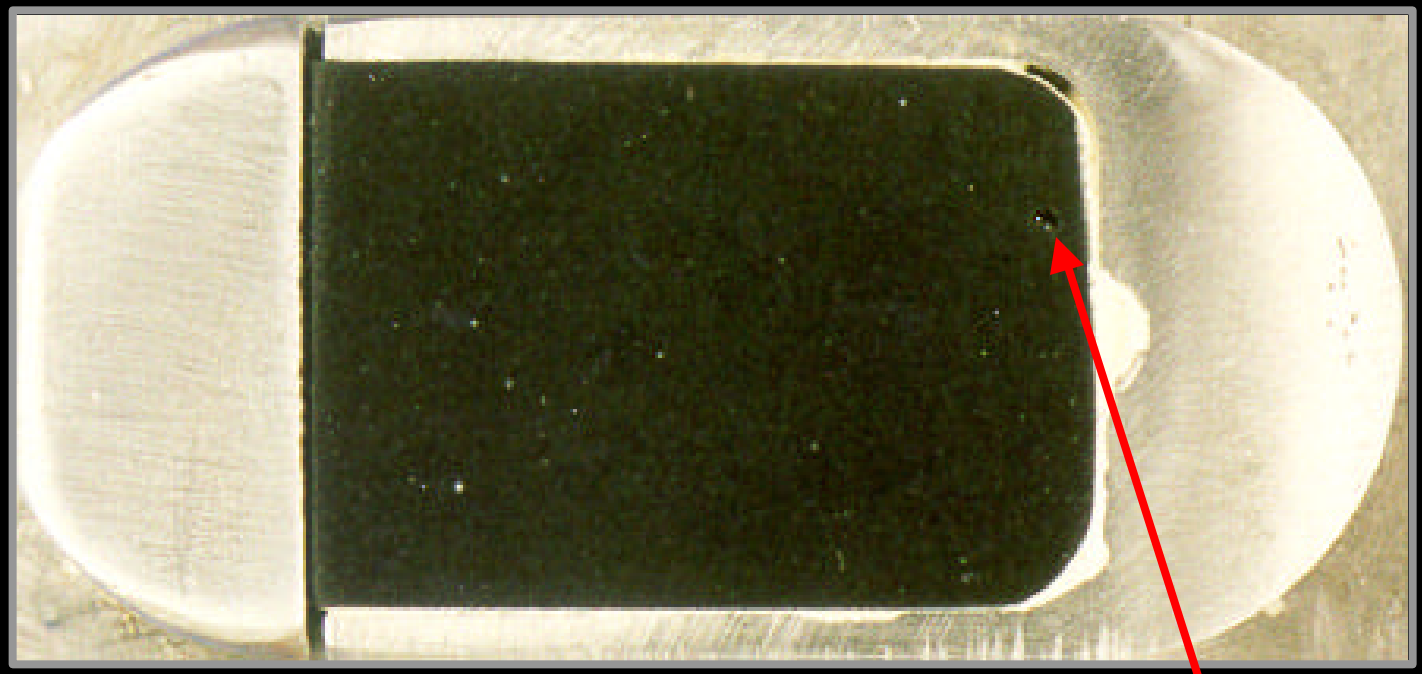
Applied Research Lab

Penn State University



INITIAL VIEW OF FIRST SAMPLE

NOTE THE SURFACE DEFECT



FIRST SAMPLE AFTER 4 HOURS

NOTE THE SURFACE DEFECT



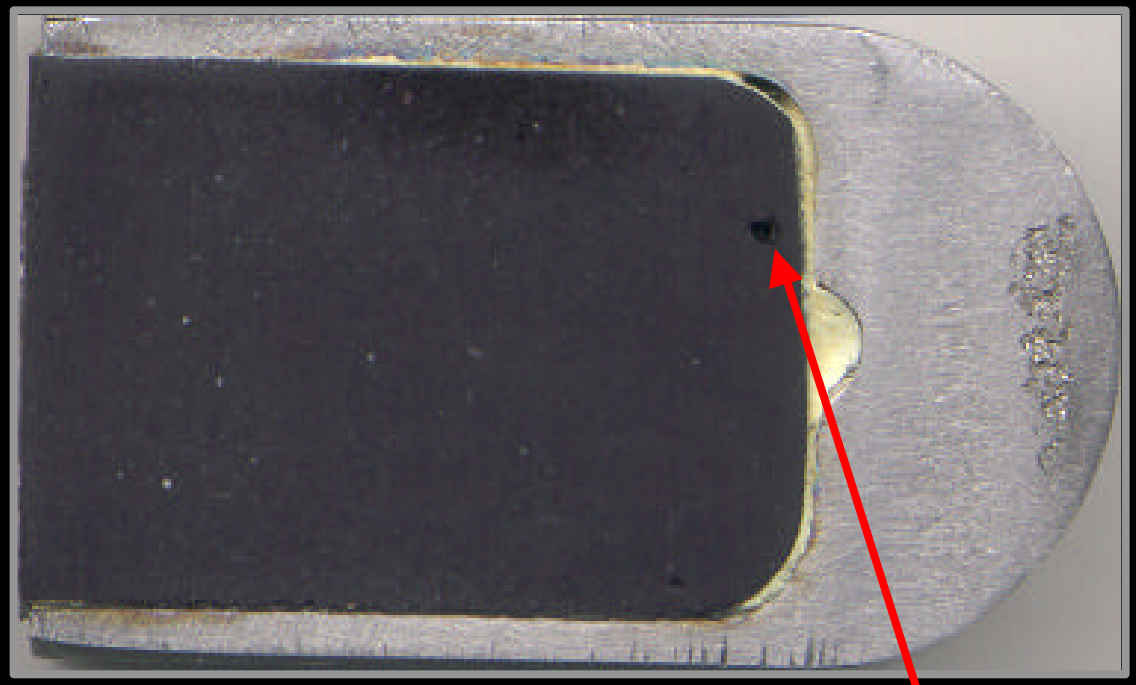
FIRST SAMPLE AFTER 9 HOURS

NOTE THE SURFACE DEFECT



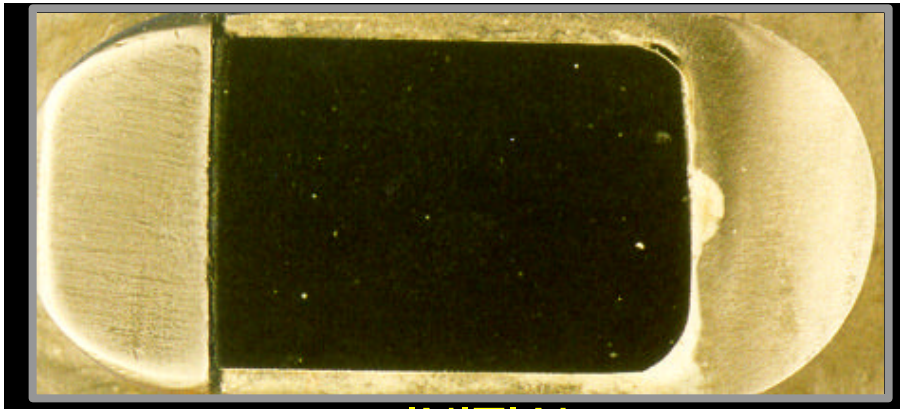
FIRST SAMPLE AFTER 15 HOURS

NOTE THE SURFACE DEFECT

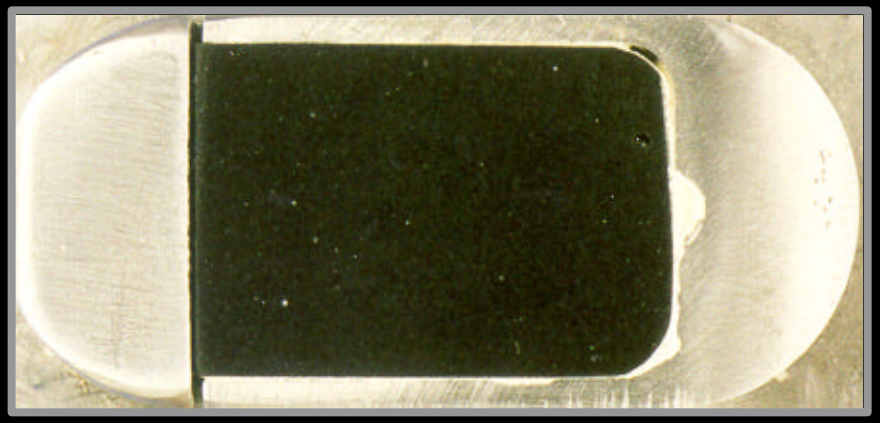


FIRST SAMPLE AFTER 20 HOURS

NOTE THE SURFACE DEFECT



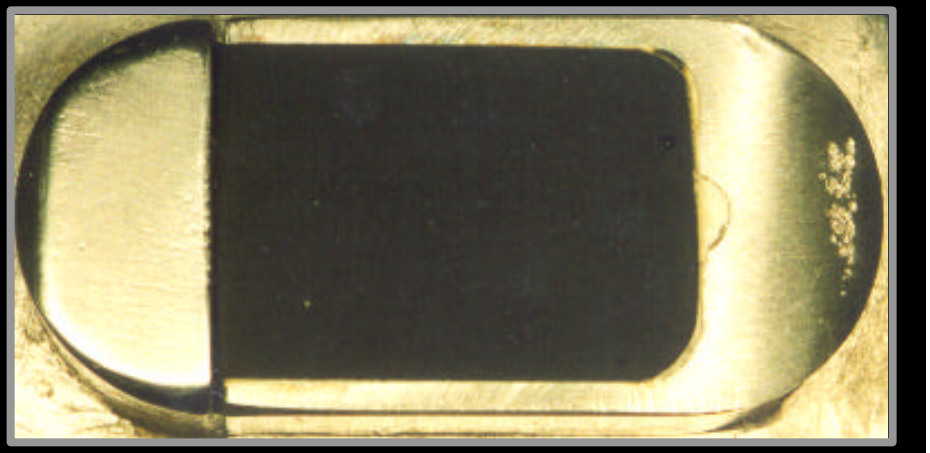
INITIAL



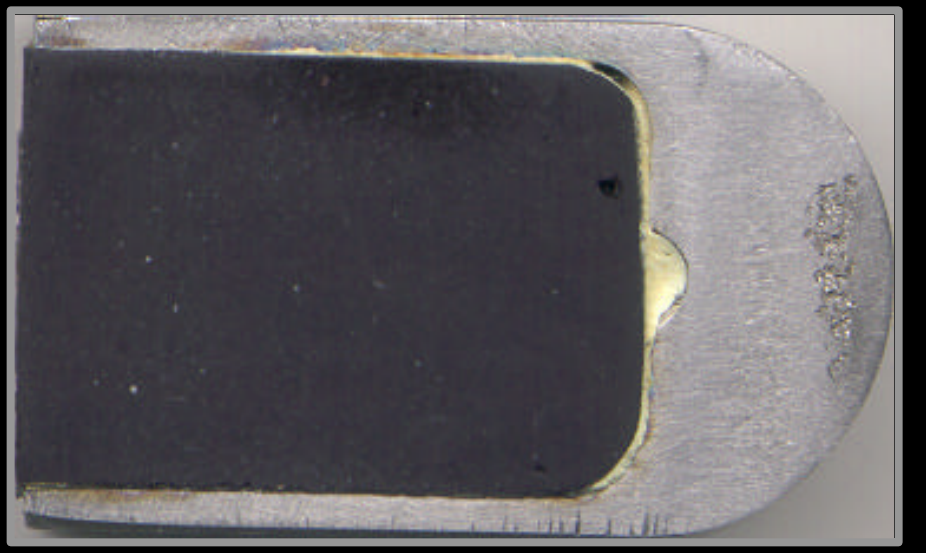
4 HOURS



9 HOURS



15 HOURS



20 HOURS

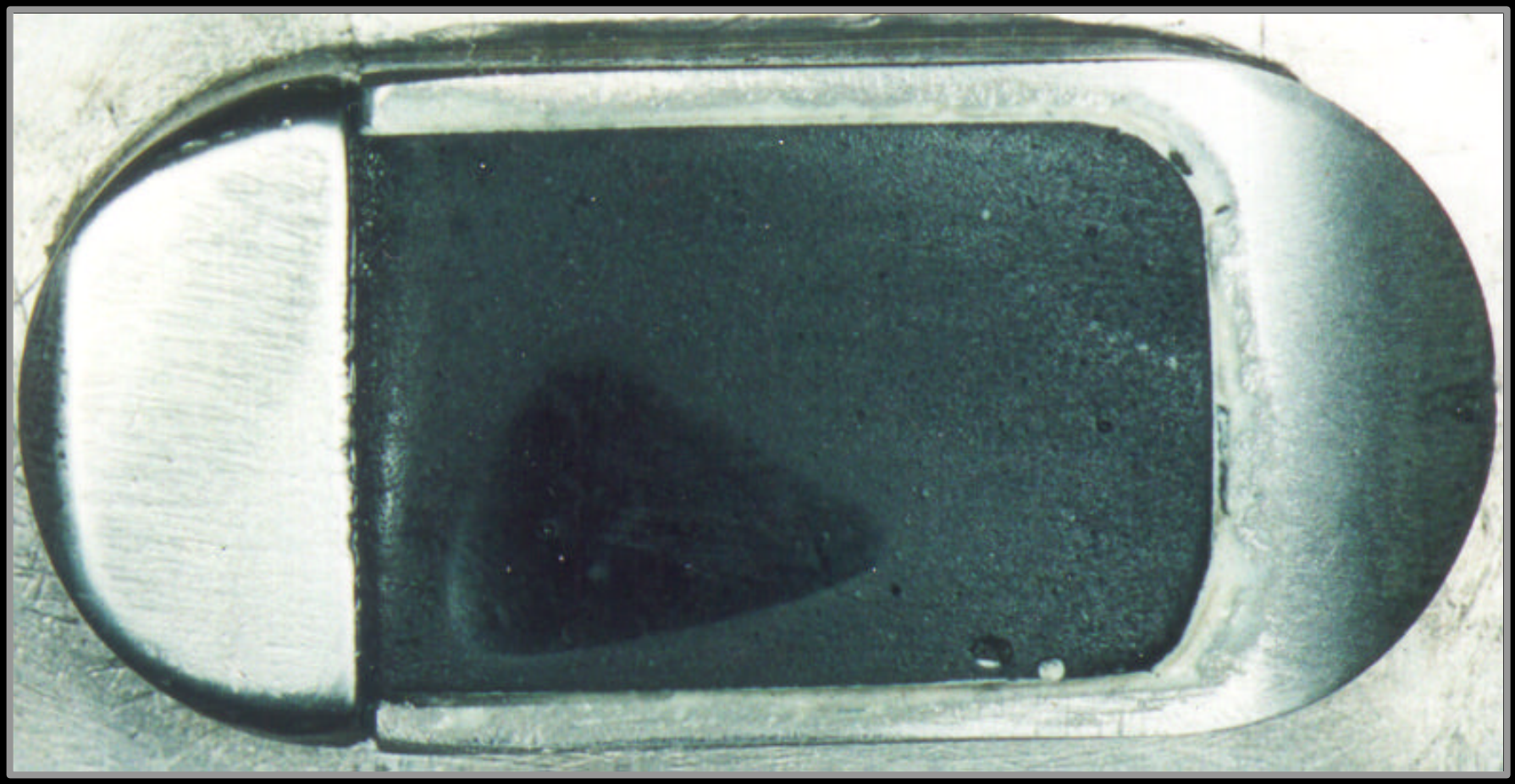
Second Sample

This sample was not prepared as carefully as the first. To some, this may indicate sloppiness. To my way of thinking, it is far more representative of a **REAL WORLD** application.

Here are the pictures of the second sample. The sample number was 525 and the number at the end corresponds to the number of hours evaluated in the tunnel (525-5 is the picture of the sample after 5 hours of testing, etc.). The surface flaws that were present did seem to open a little, however, the sample still performed well.
I will be in contact with you soon!

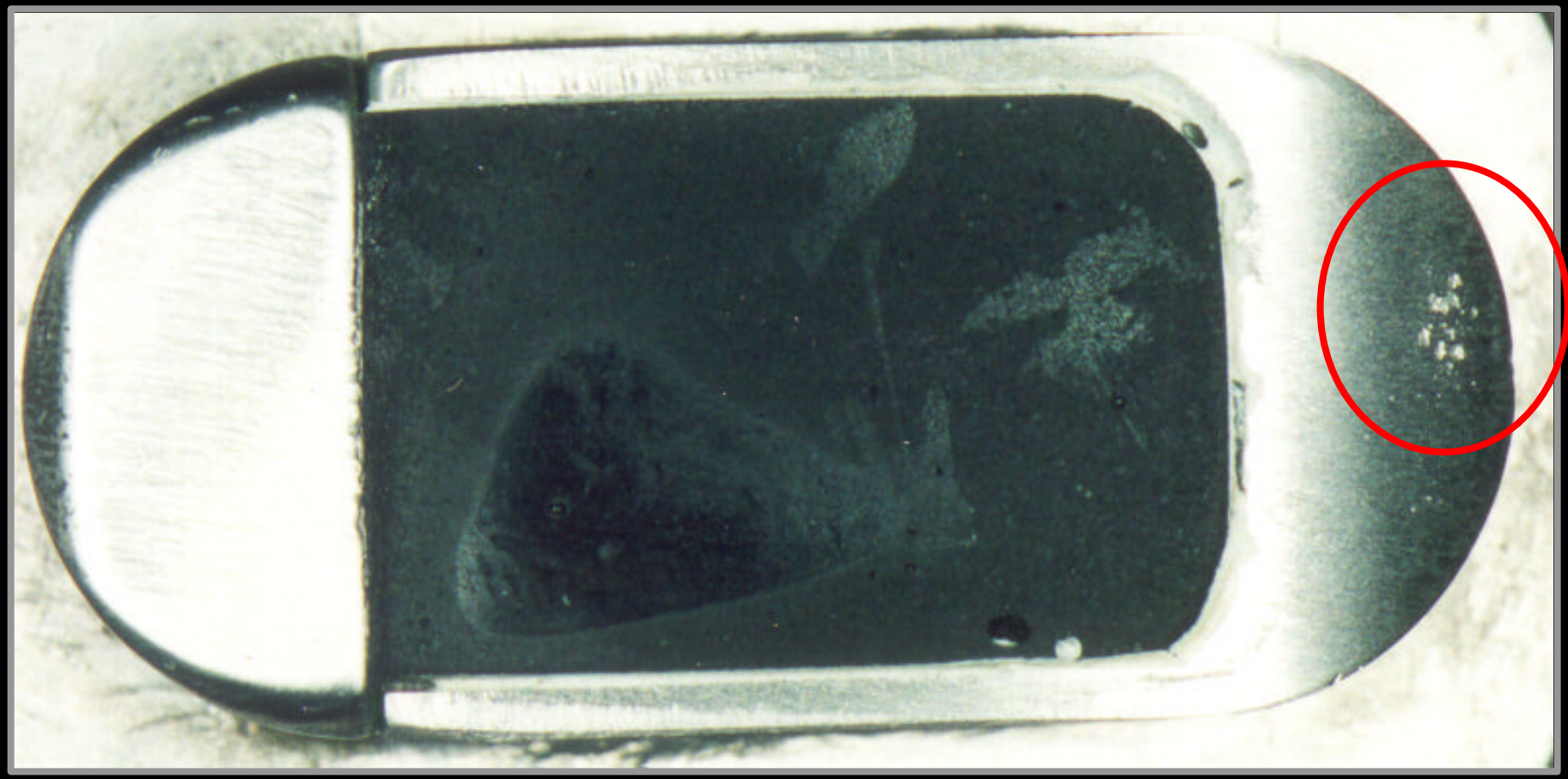
Regards,
Dan Metrey
Applied Research Lab
Penn State University

Second Sample



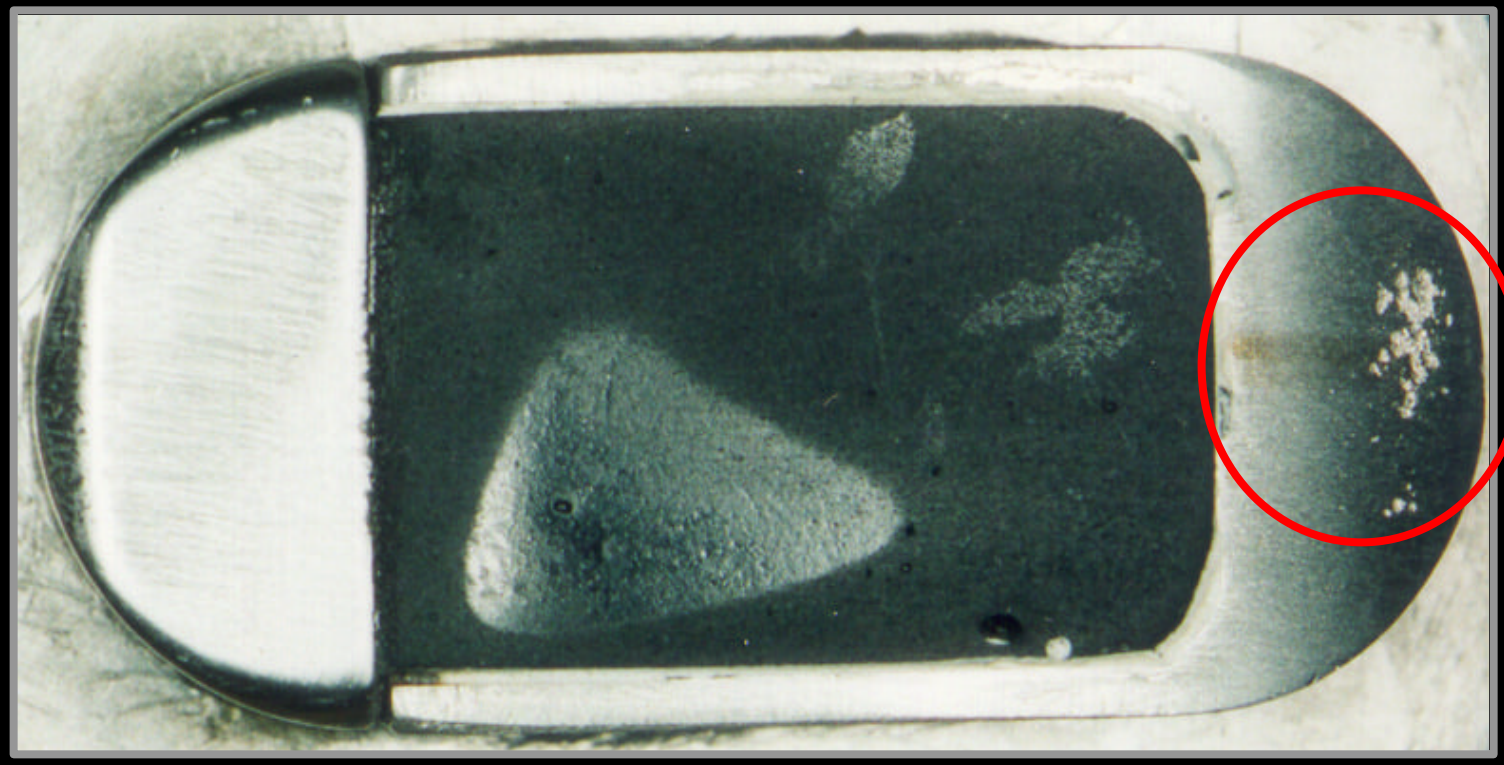
Initial view (zero hours of testing).
Note the abundance of surface defects

Second Sample



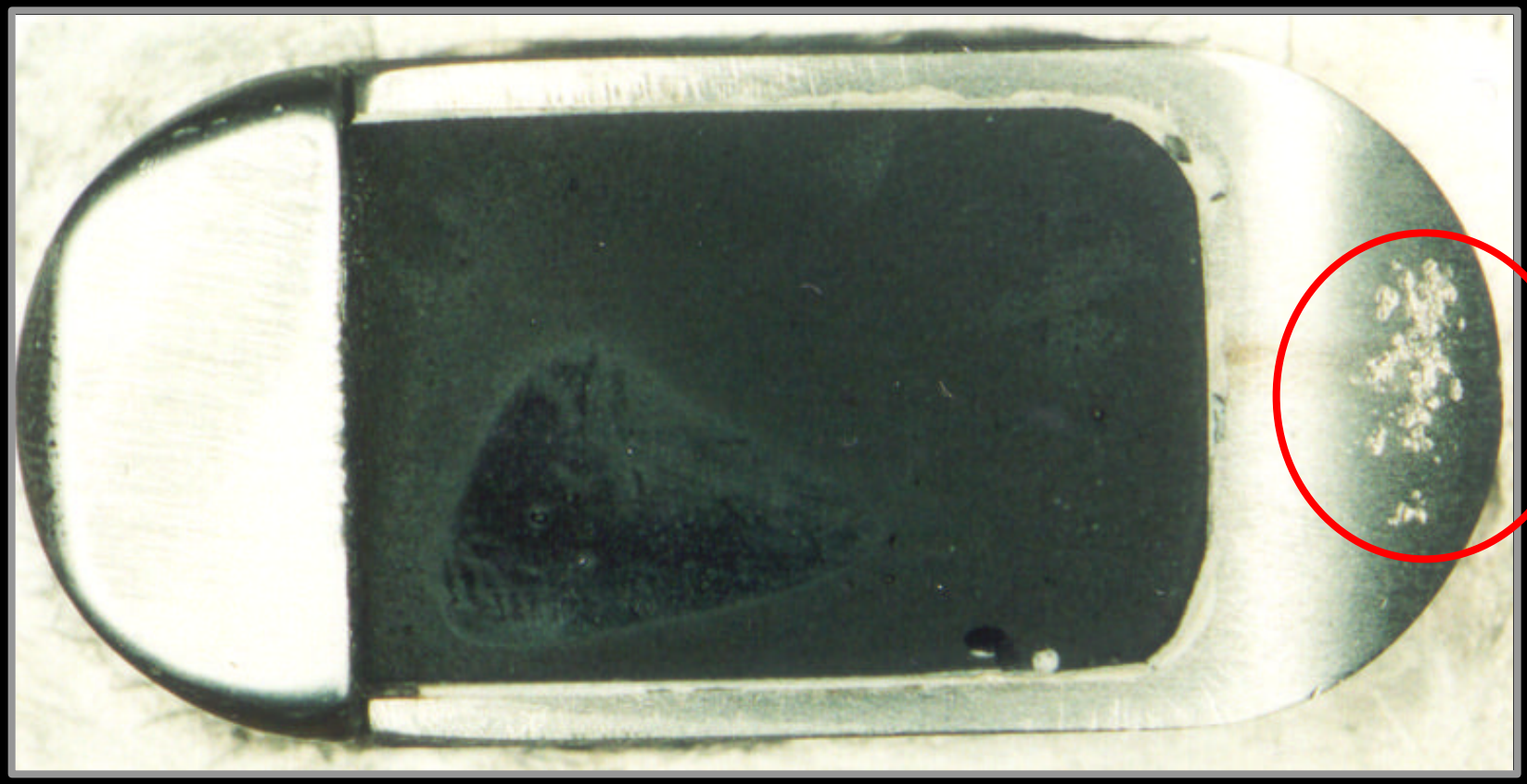
After 5 hours of testing. Surface defects appear to have remained the same. The only noticeable change is on the holder.

Second Sample



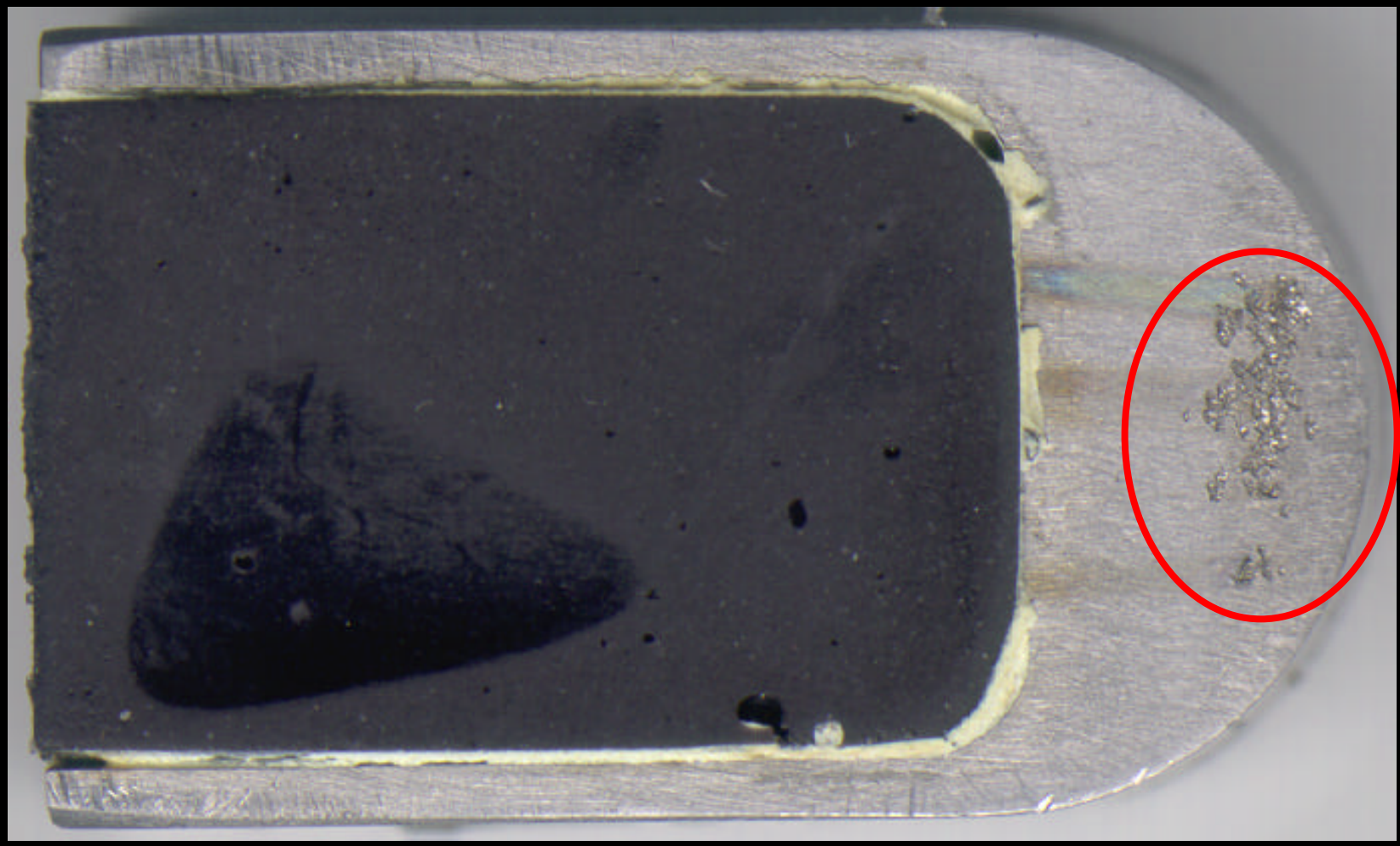
After 10 hours of testing. Very similar to the last slide with more damage visible to the holder.

Second Sample

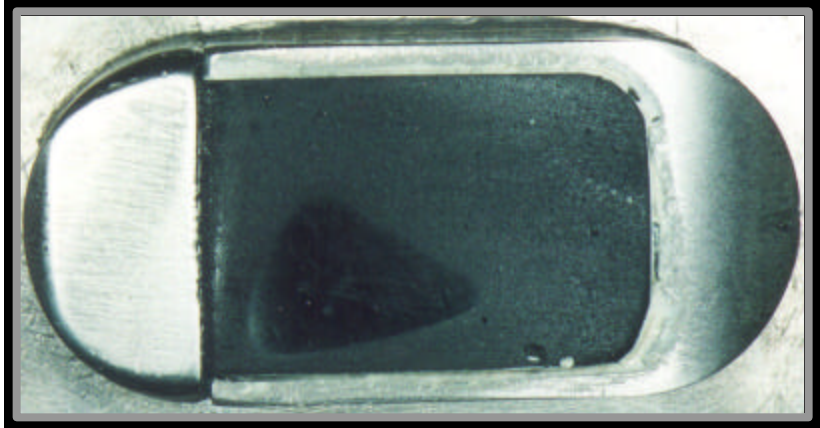


After 16 hours of testing.

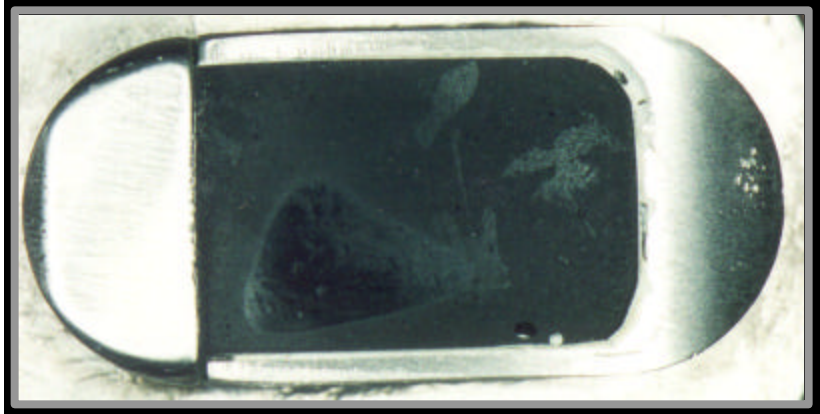
Second Sample



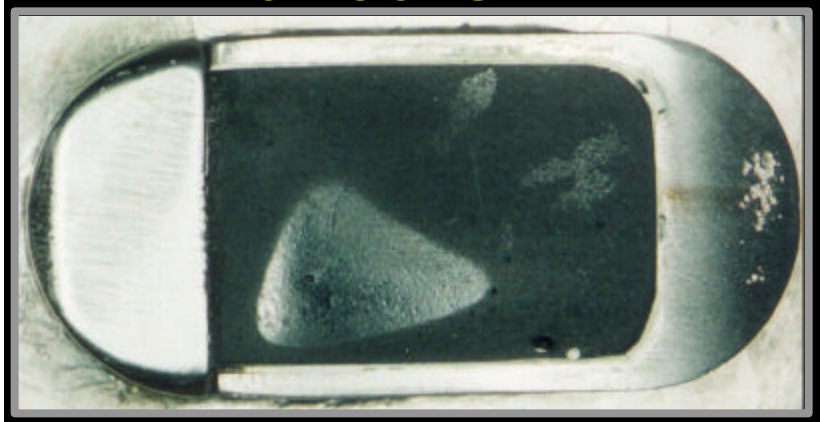
After the full 20 hours of testing.



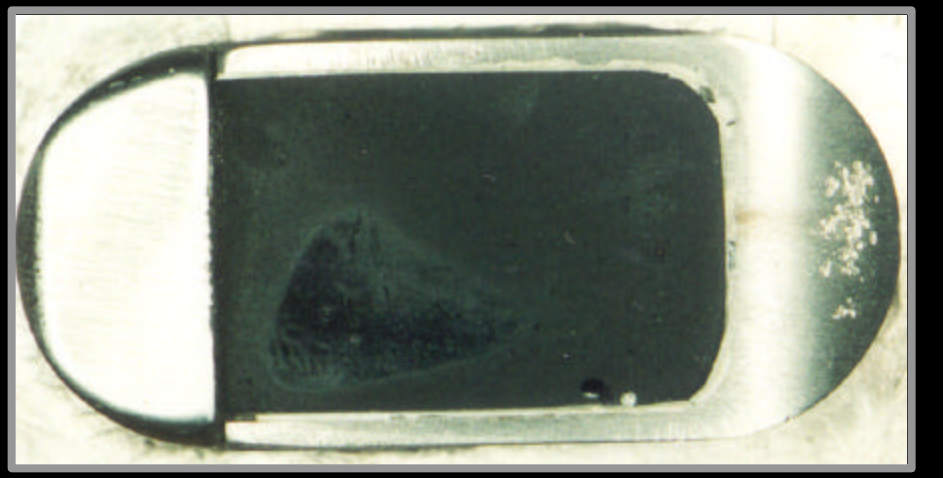
INITIAL



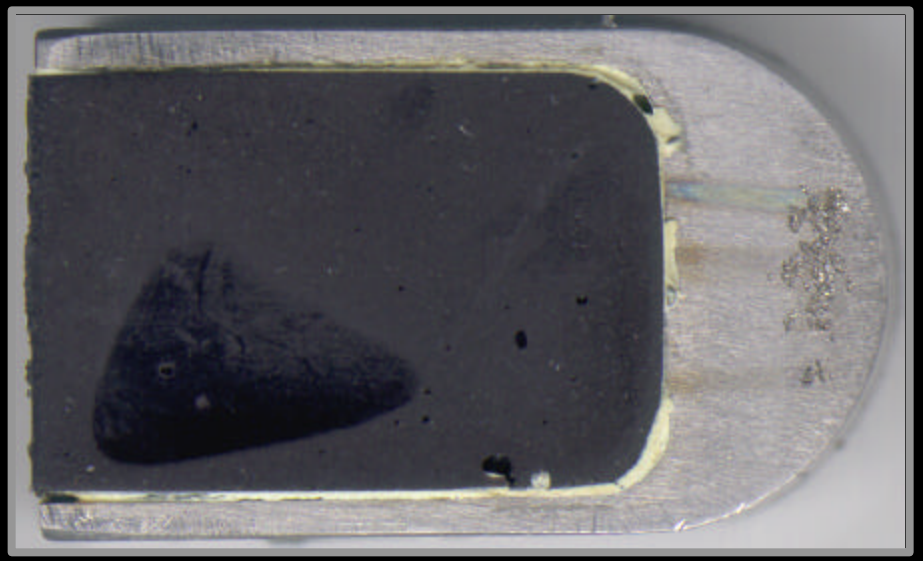
5 HOURS



10 HOURS



16 HOURS



20 HOURS

DRAFT

The coating samples could be observed through the test section windows and were removed for examination at appropriate intervals. Before evaluation of the 2141 coating, a test was conducted at 195 ft/sec using an 1100-0 aluminum sample and the resulting surface damage of

Figures 5 and 6 are a collection of photographs (for specimens 1 and 2 respectively) of the sample's condition prior to, at intermediate intervals, and at the conclusion of testing. Both samples were evaluated for the full 20 hours, showing very little damage at the conclusion of testing. While these results are favorable, it is quite possible that this material could yield even better results if applied in a uniform surface without surface flaws. In the as-received condition (prior to testing), surface flaws were present on the surface of both samples, with the second sample having a considerable depression as well. Surface flaws and uneven surfaces, when exposed to high cavitation-erosion intensity, can lead to premature or possible instant catastrophic failure. Although the evaluated samples exhibited a good resistance to damage accumulation, showing only minor opening of the flaws, it is possible that the negative effect of these defects on the coating service life could be exasperated in full-scale service. However, both coating samples exhibited extremely good cavitation-erosion resistance and, especially with the elimination of the defects, could be considered among the best materials evaluated to date in the ARL Penn State 1.5-inch ultra-high-speed cavitation tunnel for cavitation-erosion resistance. It is important to note that the water tunnel test only evaluates cavitation-erosion resistance and

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REFERENCES

Weir, D. S., Billet, M. L., and Holl, J. W., "The 1.5-inch Ultra-High-Speed Cavitation Tunnel at the Applied Research Laboratory of the Pennsylvania State University," ARL Penn State Technical Memorandum 75-188, 10 July 1975.

DRAFT

Howard,

I was finally able to talk to Dave Stinebring. As I mentioned before, the 20 hours was originally designed to relate to a specific service life of a specific application, however, we have found that 20 hours at the 195 ft/sec velocity remains a suitable bench march for other applications as well. Dave explained to me that the relative hours of service life are proportional to the sixth power of the relative velocity. I am probably not explaining this very well or using the proper mathematical words, so, I will give you an example. As you know, we run our test at 195 ft/sec, which is relatively fast. If water flow of velocity of say 100 ft/sec was triggering (for lack of a better word) cavitation in a certain application and a sample of the material tested in the water tunnel lasted 20 hours at 195 ft/sec, then the following rough relationship could be made:

(195 ft/sec / 100 ft/sec)^6 = ~ 55

55 * 20 = 1100 hours of service

It should be noted that this relationship only takes into account cavitation erosion and not other factors such as adhesion, corrosion, etc..

BOTTOM LINE

WHAT DOES ALL THIS MEAN FROM A PERFORMANCE POINT OF VIEW?

BASED ON A PROPELLER OPERATING AT 70% EFFICIENCY
A VESSEL TRAVELING AT:

40 KTS COULD EXPECT TO SEE **134** SERVICE DAYS AT THIS SPEED!

35 KTS COULD EXPECT TO SEE **295** SERVICE DAYS AT THIS SPEED!

30 KTS COULD EXPECT TO SEE **750** SERVICE DAYS AT THIS SPEED!

25 KTS COULD EXPECT TO SEE **2224** SERVICE DAYS AT THIS SPEED!

20 KTS COULD EXPECT TO SEE **8481** SERVICE DAYS AT THIS SPEED!

FOR YEARS, THE UNITED STATES NAVY HAS USED AER 48E FOR CAVITATION PROTECTION WITH MIXED RESULTS.

LET'S COMPARE THE TWO PRODUCTS:

PERFORMANCE SUMMARY

TEST	AER 48E TESTED	BELZONA 2141 TESTED
ASTM D412 ELONGATION AT BREAK, %	**84%**	**530%**
ASTM D412 TENSILE STRENGTH, PLI	**1,800**	**2,200**
ASTM D624 TEAR STRENGHT, PLI	**148**	**380**
SHORE A HARDNESS	**88**	**87**
ASTM D4060 DRY SLIDING ABRASION WEAR **LOSS**, CUBIC MM.	**177**	**50**

PERFORMANCE SUMMARY

TEST	AER 48E TESTED	BELZONA 2141 TESTED
ASTM D4060 WET SLIDING ABRASION WEAR **LOSS**, CUBIC MM.	**1,399**	**39**
PENN STATE ARL CAVITATION TUNNEL-TIME TILL FAILURE	**11-17 HOURS TO FAILURE**	**20 HOURS NO FAILURE NOTED**

SIMPLY STATED: **BASED ON TESTS, A SUPERIOR PRODUCT!**

THANK YOU
for
YOUR ATTENTION

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