ACCELERATED AGING TEST RESULTS FOR AEROSPACE WIRE INSULATION CONSTRUCTIONS

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ABSTRACT

Several wire insulation constructions were evaluated with and without continuous glow discharges at low pressure and high temperature to determine the aging characteristics of acceptable wire insulation constructions. It was known at the beginning of the test program that insulation aging takes several years when operated at normal ambient temperature and pressure of 20°C and 760 torr. Likewise, it was known that the accelerated aging process decreases insulation life by approximately 50% for each 10°C temperature rise. Therefore, the first phases of the program, not reported in these test results, were to select wire insulation constructions that could operate at high temperature and low pressure for over 10,000 hours with negligible shrinkage and little materials deterioration. The final phase of the program was to determine accelerated aging characteristics.

When an insulation construction is subjected to partial discharges the insulation is locally heated by the bombardment of the discharges, the insulation is also subjected to ozone and other deteriorating gas particles that may significantly increase the aging process. Several insulation systems using either a single material or combinations of teflon, kapton, and glass insulation constructions were tested. All constructions were rated to be partial discharge and/or corona-free at 240 volts, 400 Hz and 260°C (500°F) for 50,000 hours at altitudes equivalent to the Paschen law minimum partial discharge aging tests were preceded by screening tests lasting 20 hours at 260°C. The aging process was accelerated by subjecting the test articles to temperatures up to 370°C (700°F) with and without partial discharges. After one month operation with continuous glow discharges surrounding the test articles, most insulation systems were either destroyed or became brittle, cracked, and unsafe for use. Time with space radiation as with partial discharges is accumulative.

INSULATED CONDUCTOR LIFE

Conductor life will last decades of years when operated at normal ambient temperature ±20°C. When operated with partial discharges the insulation is heated by the discharges, the insulation oxidized and life shortened to 10 to 500 hours depending upon the partial discharge intensity and applied voltage. Several tests were performed at Boeing using aircraft teflon insulated conductors at 23±10°C, 400 Hz, and 240±5 Vrms. After one month the insulation was brittle, cracked, and unsafe for further use. Time with partial discharges is accumulative. The time may be continuous as in an experiment or in short bursts over several years.

AEROSPACE WIRE INSULATION CONSTRUCTIONS SELECTED FOR TEST

TEST ARTICLES

8---Manufacturers Supplied Test Articles
25--Wire Insulation Constructions
12--Test Articles Per Wire Construction Were Evaluated

INITIAL SCREEN TESTS

Visual Inspection
Dielectric Strength
Insulation Resistance
Fluid Resistance
Wrap
Shrinkage after 20 hours at 260C
Abrasion Resistance
Weight loss after 20 hours at 260C

All test articles passed the initial screening test

ACCELERATED AGING TESTS AND RESULTS

TEMPERATURE ALTITUDE TEST PARAMETERS

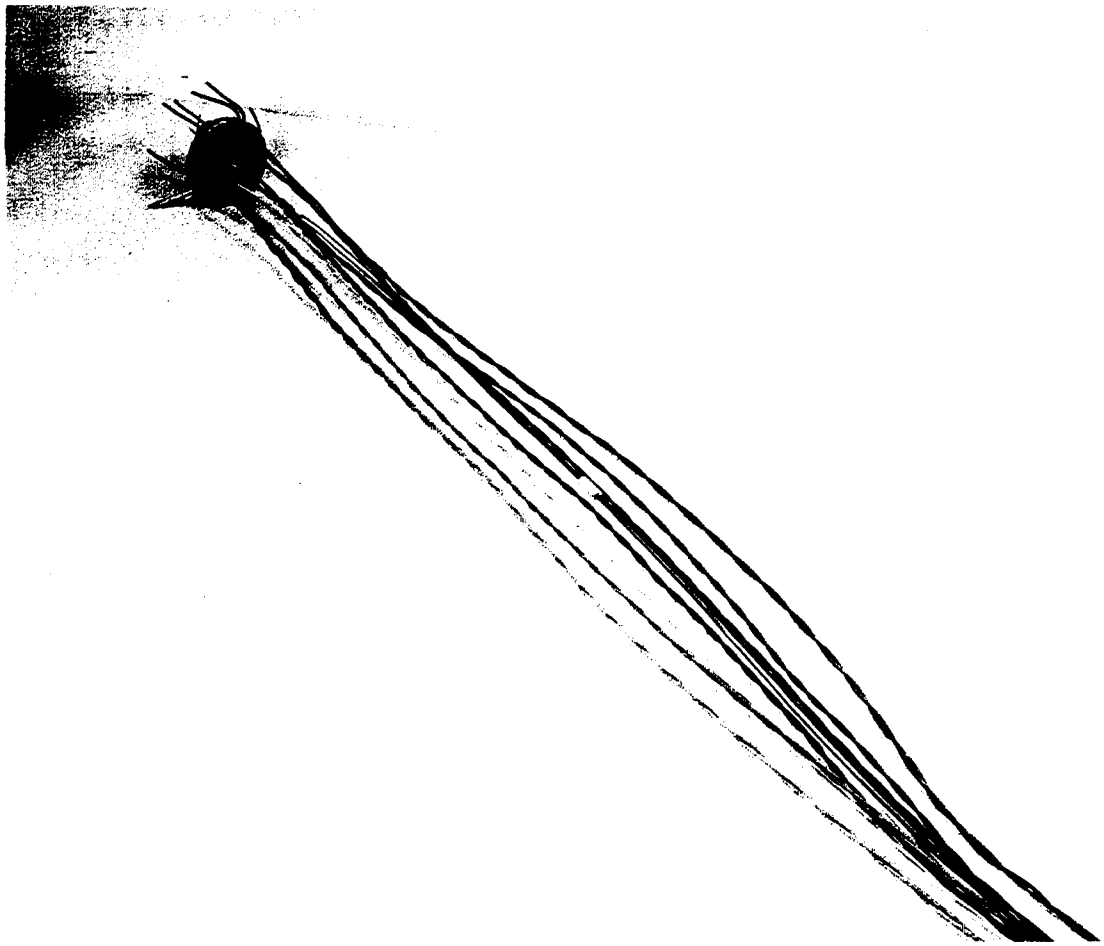
TEMPERATURE C	TIME Hours
371	336
357	504
343	1,440
321	3,888
312	8,760
304	13,200

Total test time	28,128 hours
Time at maximum temperatures	15,000 hours
Time at 21 torr	15,000 hours
Time at 760 torr and 30C	11,250 hours
Transition time (temperature, pressure)	1,878 hour

Thermal Aging Test Results

20 Wire Insulation Constructions Failed
5 Wire Insulation Constructions Passed *

* Most wire constructions had some shrinkage, minimal weight loss, and on some, the teflon oozed through glass braids.



AGING TEST RESULTS

Partial Discharges

The lower the insulation system dielectric constant the higher the partial discharge initiation voltage for equal thickness insulation systems tested with ac

Increasing the insulation system increases the initiation voltage somewhat.

Outgassing insulation systems tends to generate EMI that must be considered when taking initiation voltage measurements.

Aging

Teflon insulation tended to roughen(polymerize) and crack with continued aging with and without glow discharges.

The binders for wraped Kapton insulation systems tended to outgas and evaporate allowing the kapton to unwind. With glow discharges the Kapton darkened and the insulation resistivity dropped significantly.

Kapton-Teflon insulation systems had many punctures between the Kapton wraps.

Glass braid over Teflon had color leaching and some of the teflon tended to ooze through the glass braid. All samples survived the 2,000 hours testing with and without glow discharges-but some samples appeared visually poor.

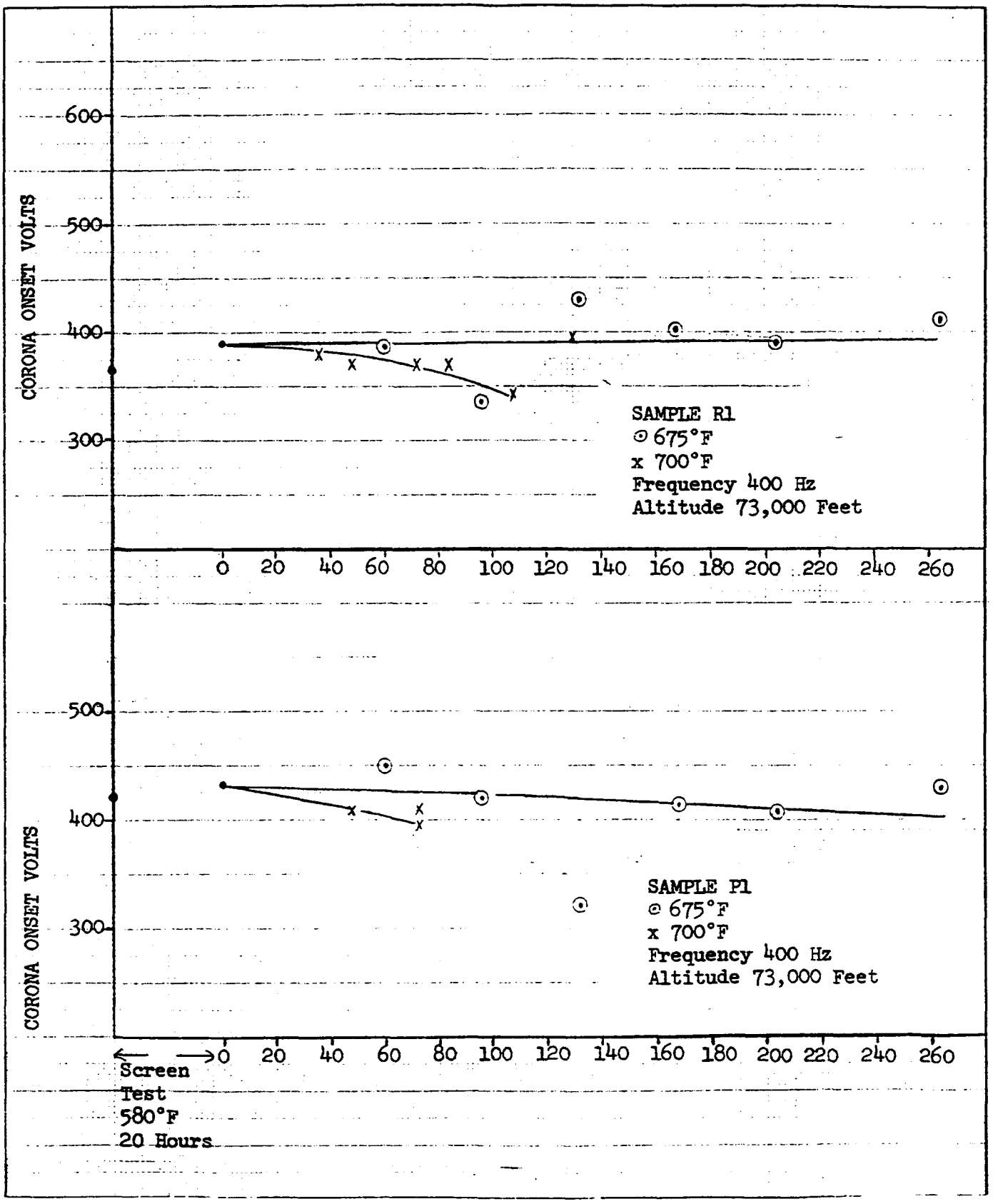


FIGURE 6.5-36 COV AS A FUNCTION OF THERMAL AGING

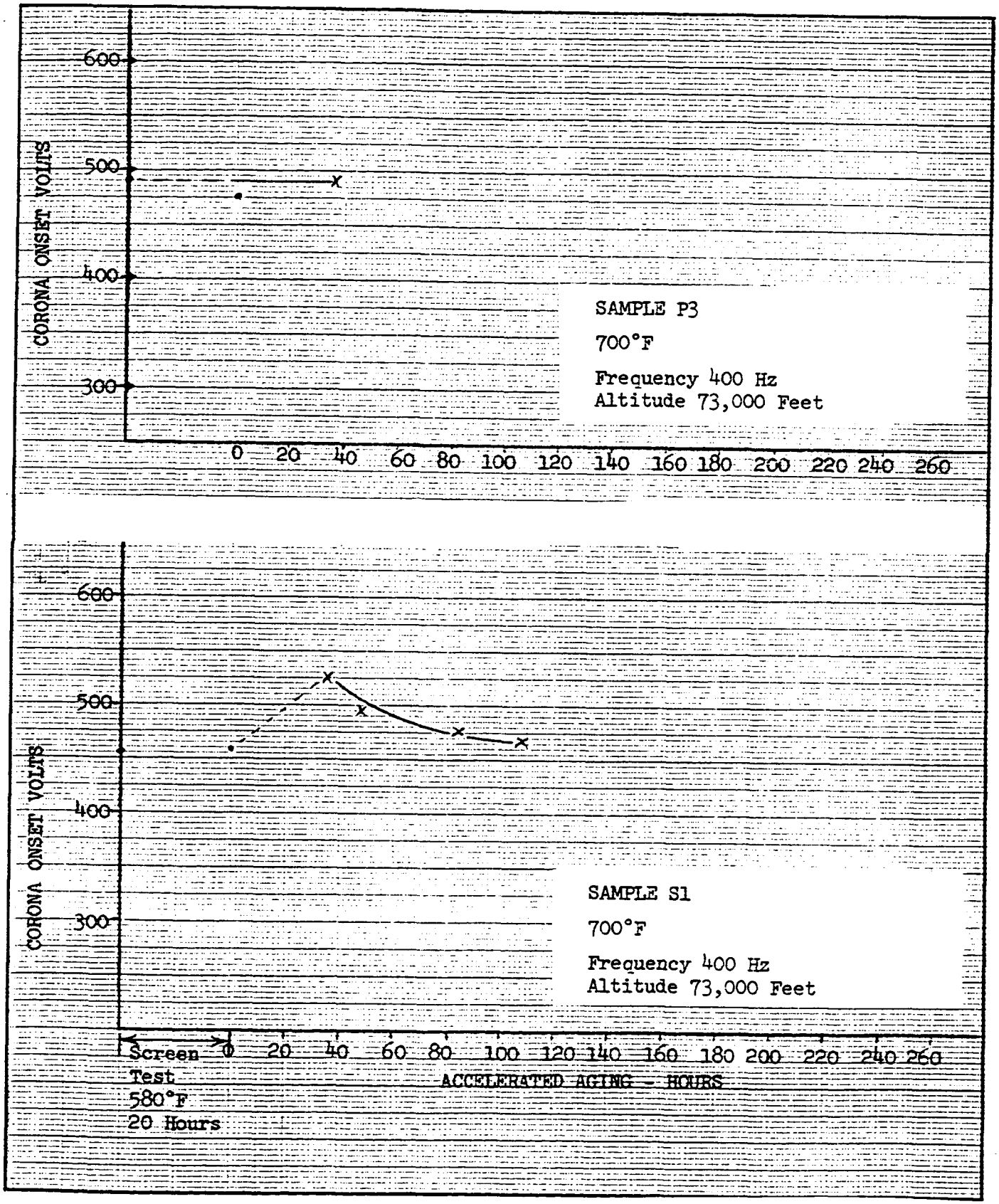
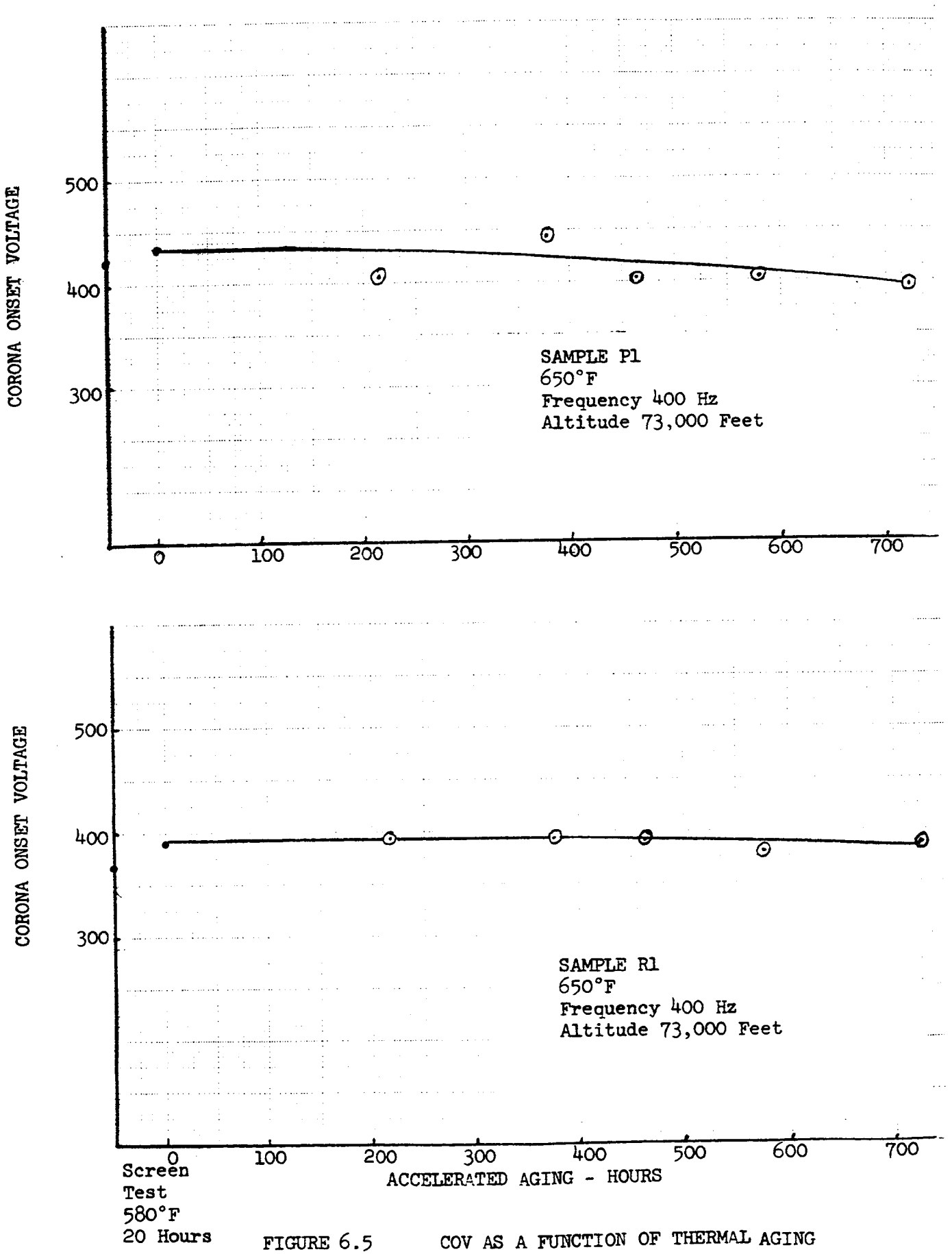


FIGURE 6.5- COV AS A FUNCTIONING OF THERMAL AGING



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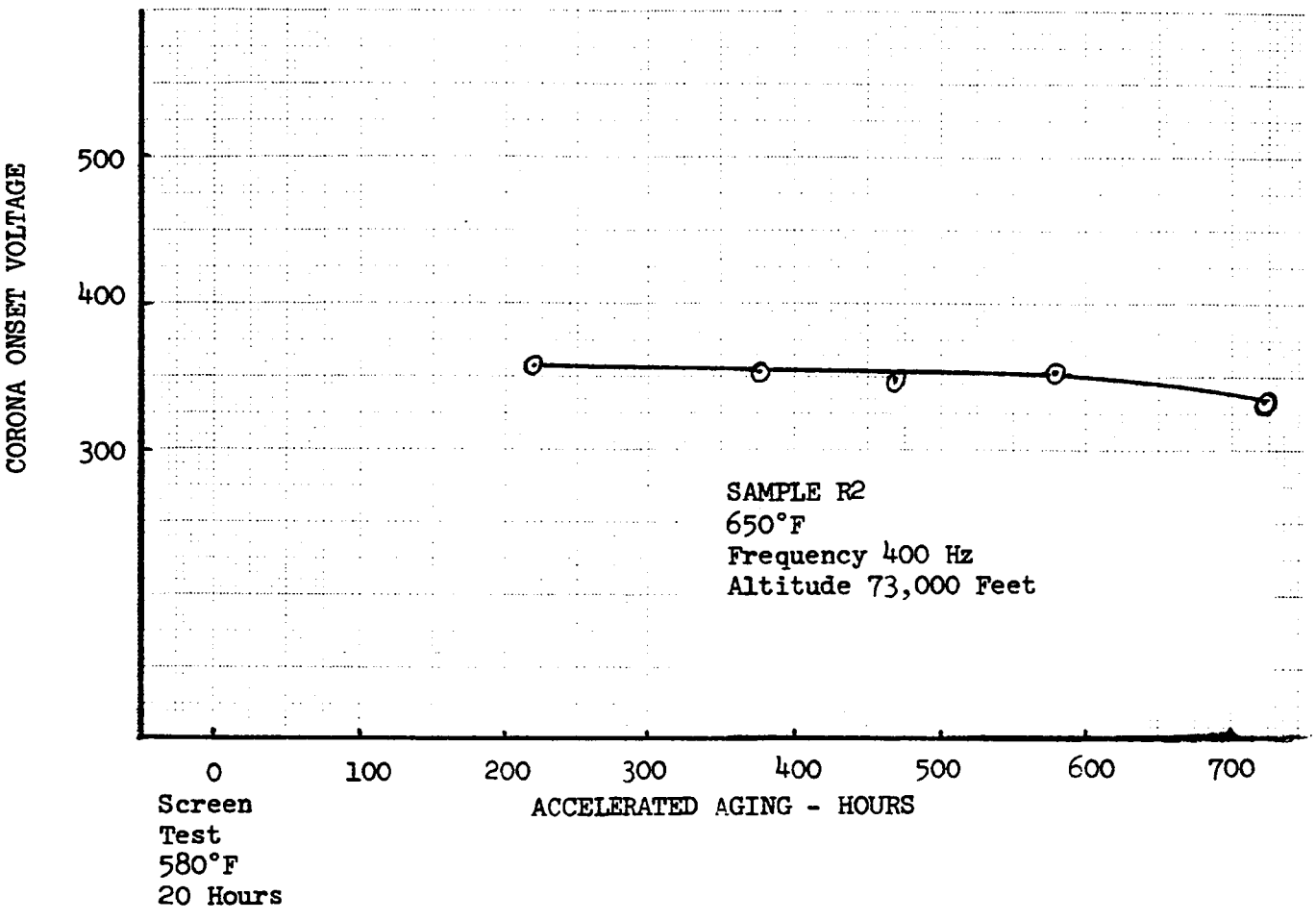

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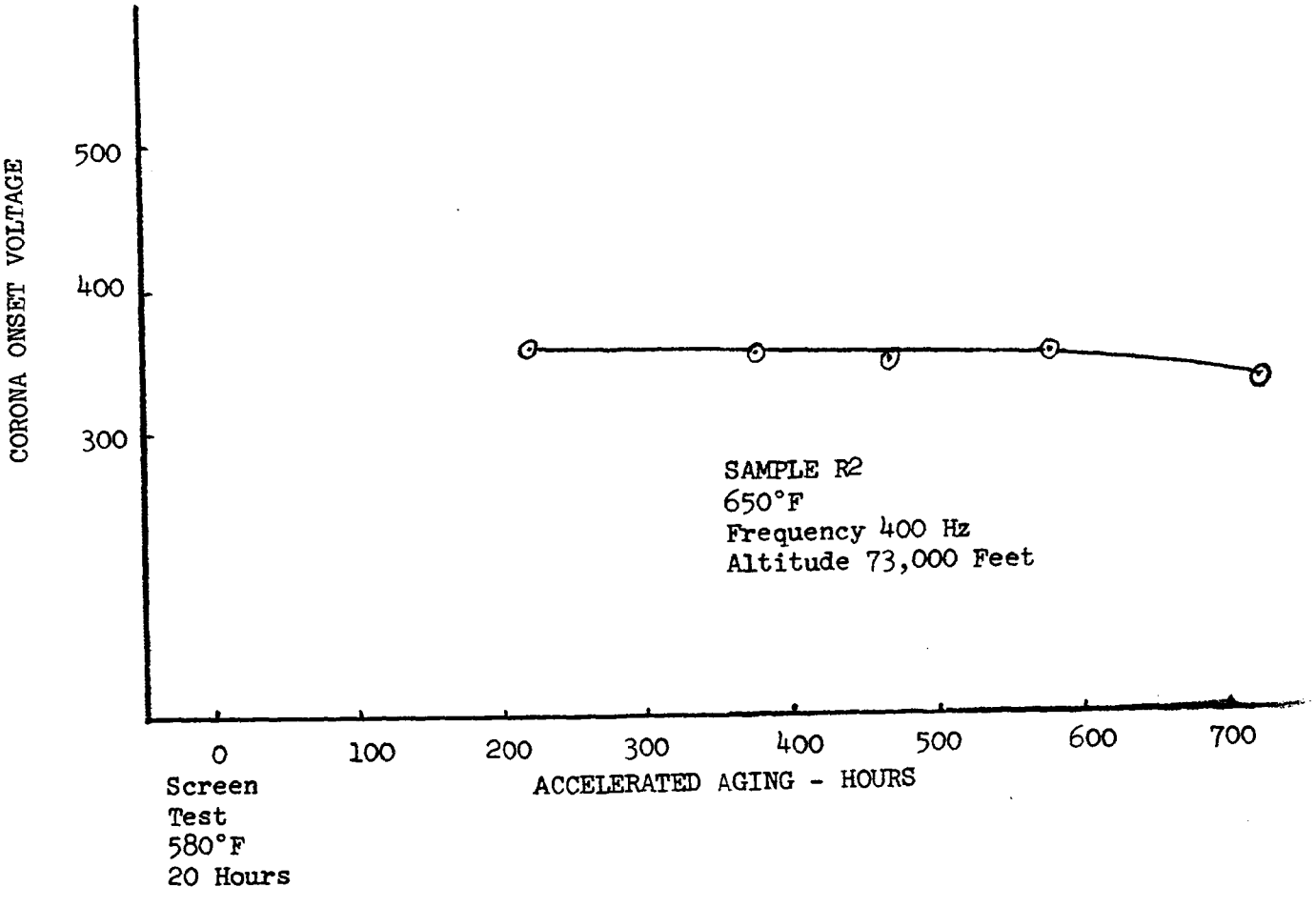
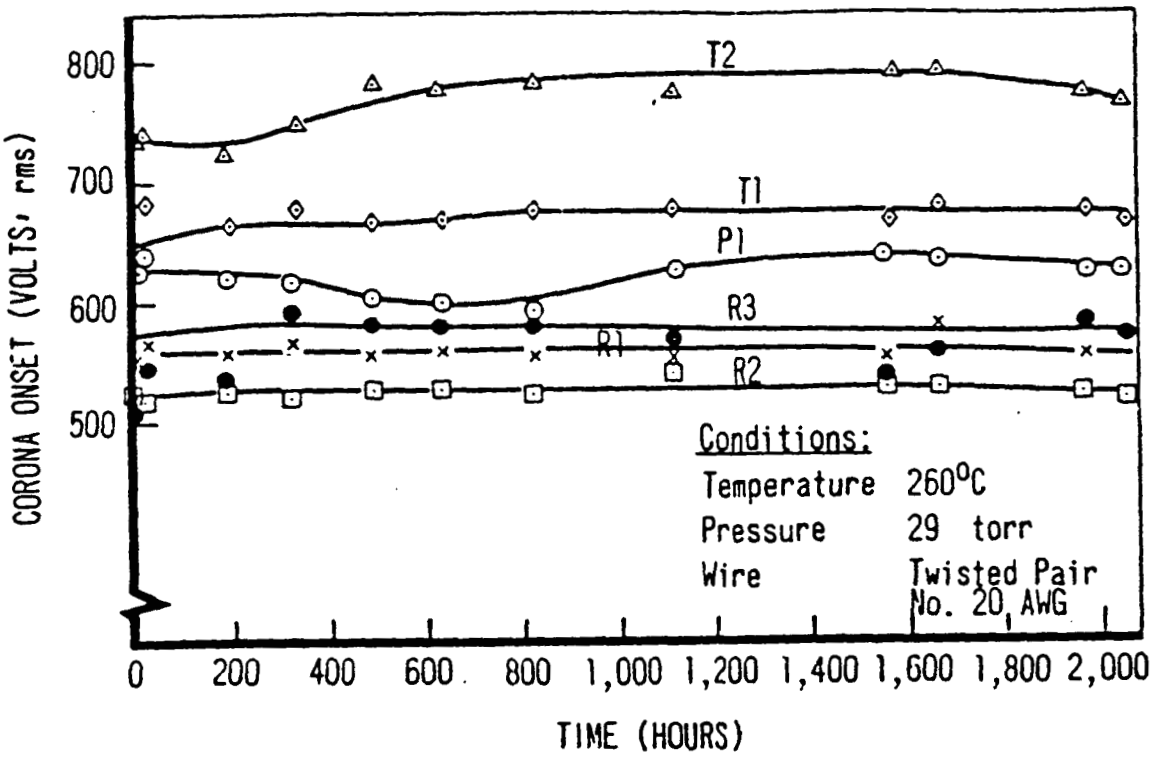


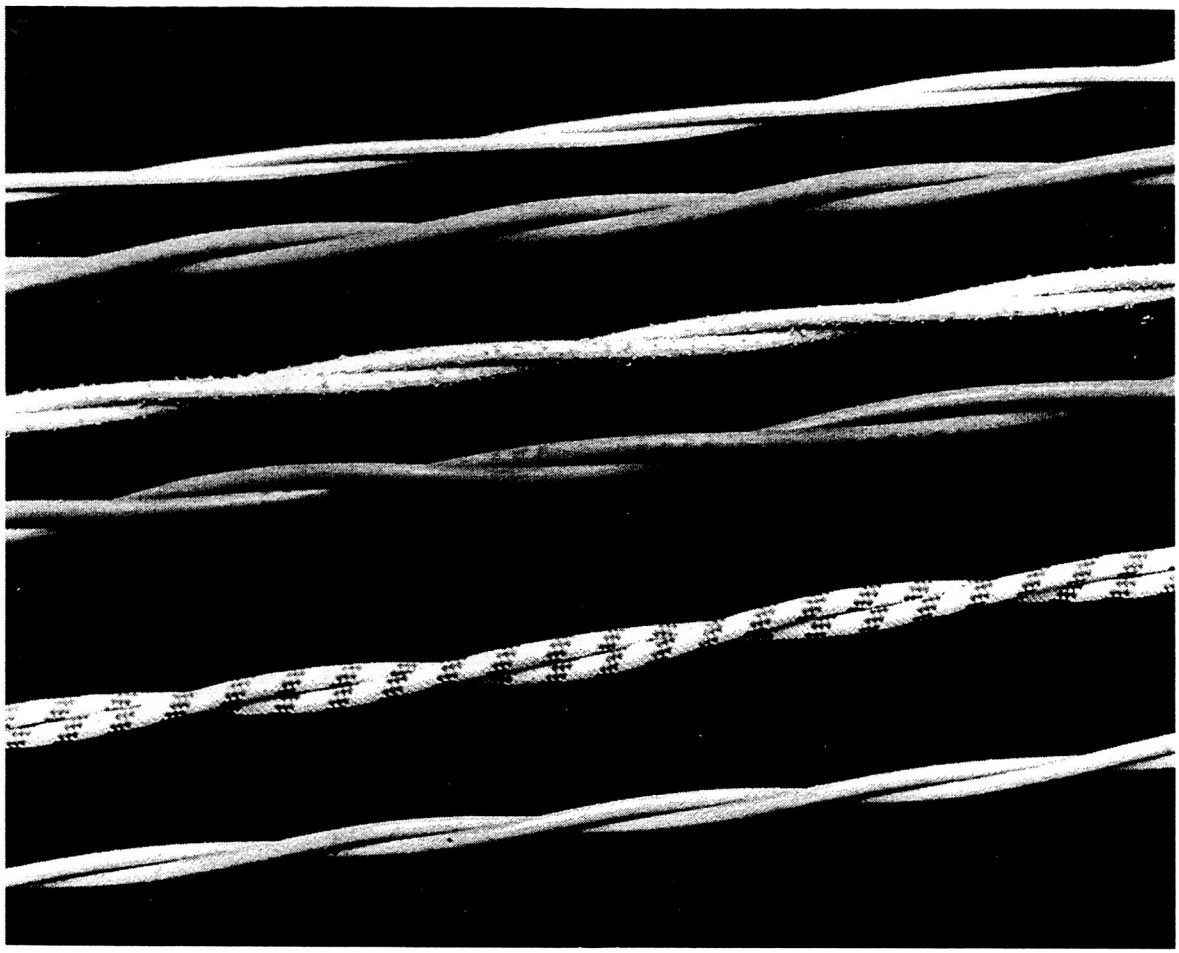
FIGURE 6.5 COV AS A FUNCTION OF THERMAL AGING

THE EFFECT OF TIME AND TEMPERATURE ON COV



Wire Specimen Materials

Specimen Number	Material Thickness, CM	Dielectric Materials
P1	0.047	Glass covered teflon
R1	0.048	Glass covered teflon
R2	0.036	Polyimide covered teflon
R3	0.036	Polyimide covered teflon
T1	0.056	Teflon
T2	0.065	Teflon



HIGH TEMPERATURE CORONA
AND
ACCELERATED AGING TESTS

CORONA AND PARTIAL DISCHARGE TESTS

High temperature partial discharge and corona tests were obtained by inserting the wire samples inside an oven constructed of lightweight firebrick. The oven was placed inside a vacuum chamber to attain depressurization. The pressure was kept between 0.1 and 2 torr.

The parallel twisted insulated wires were centered within a 4 0 inch diameter thin-wall stainless steel tube for equal temperature distribution for the full length of of the wire pair. The stainless steel tube was grounded to eliminate EMI conducted or radiated to the tube by the heater and heater electronic control elements.

The test wires were held in place with porcelain insulators--one fixed and the other spring loaded to provide tension to the test wires. All metal edges were rounded and taped to prevent discharges from forming in areas not under test

The temperature along the surface of the test articles was measured to be within +or-10C along the test article surface for a length of 30 inches.

ACCELERATED AGING TESTS

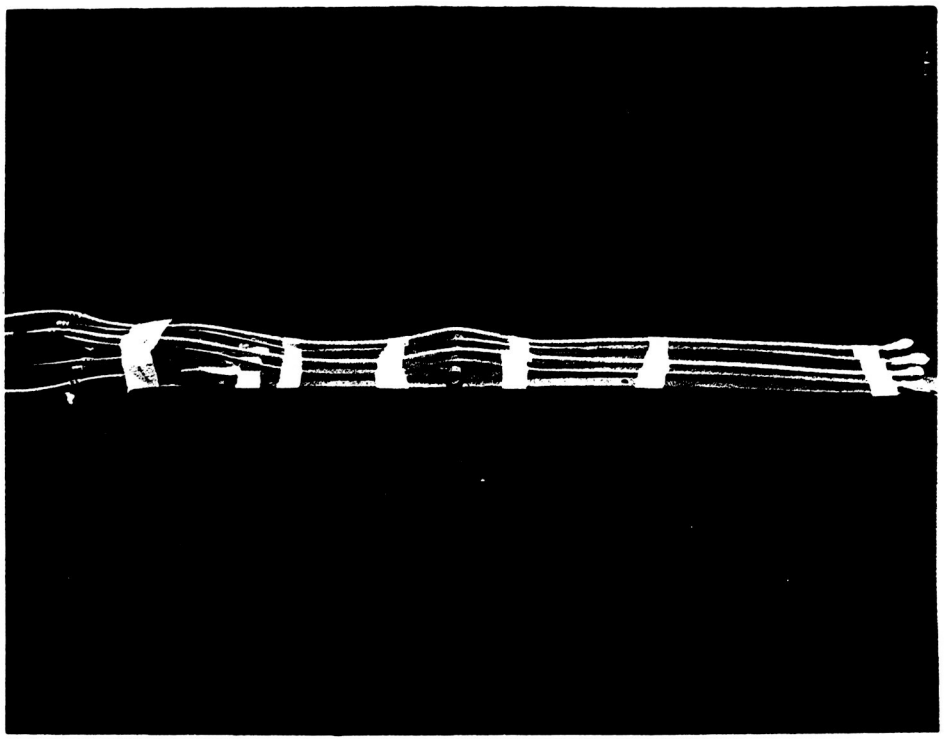
Accelerated aging tests were with and without a continuous glow discharge surrounding the test articles. The glow discharge was selected to simulate overvoltage conditions that may exist in a malfunctioning power system.

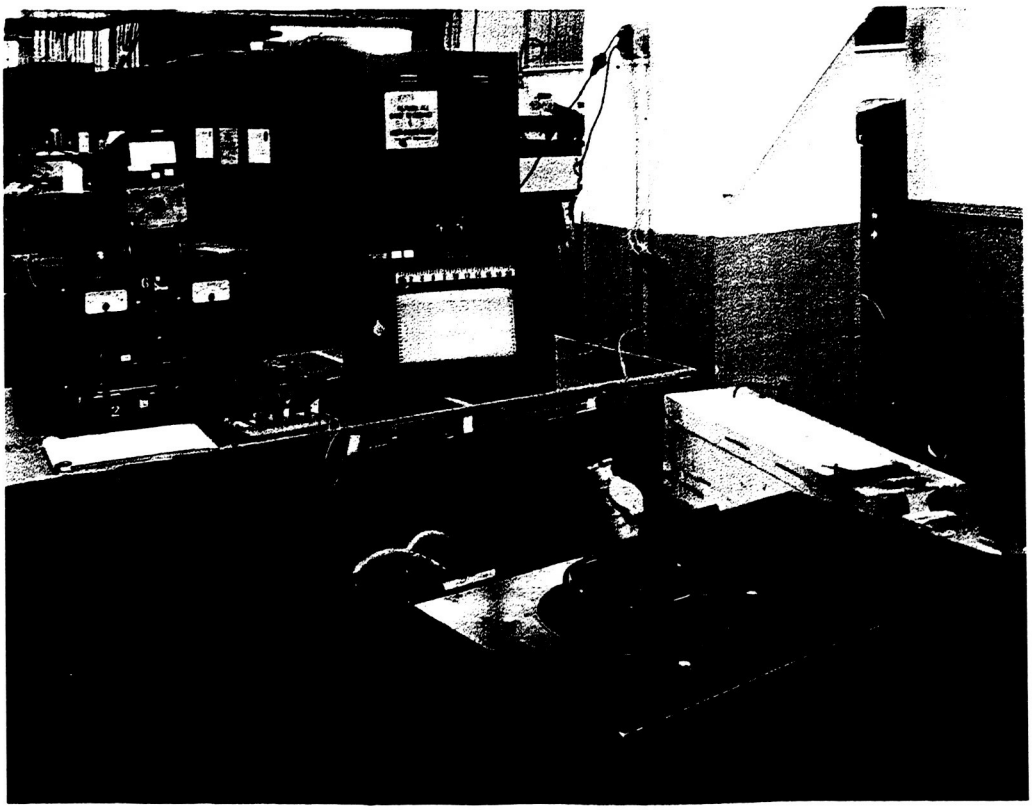
Temperature Aging

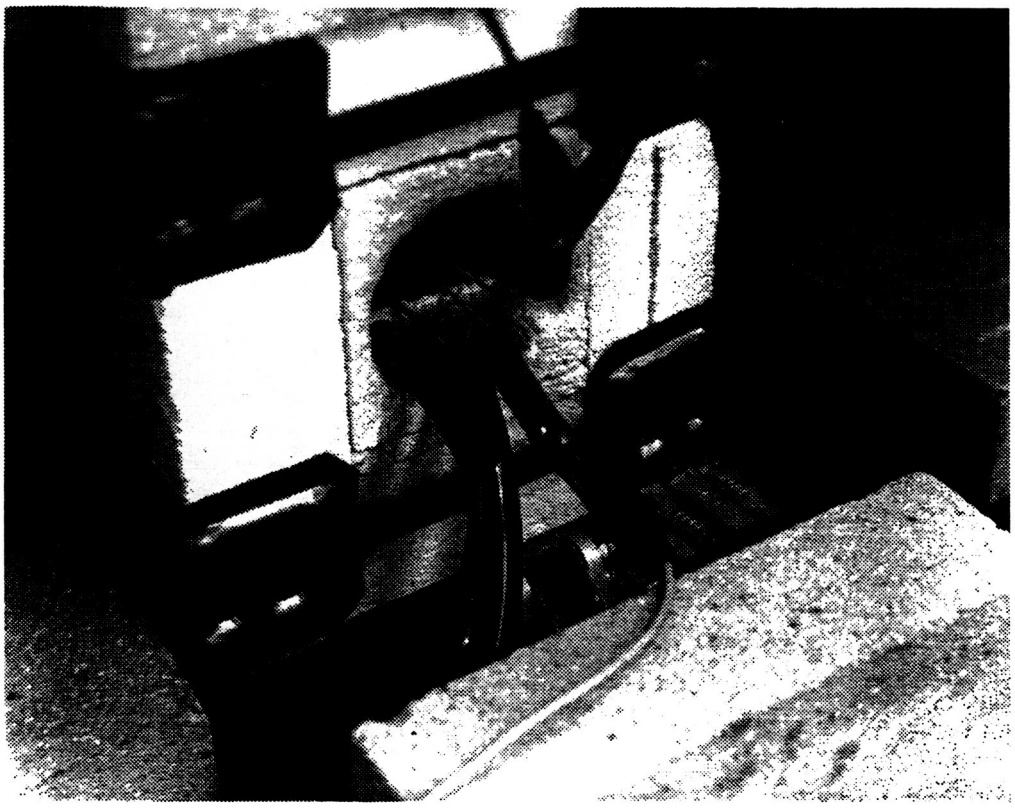
One group of seven insulated wire samples were attached to a metal ground plane to obtain wire to ground life information. Another group of seven twisted wire samples were tested to obtain twisted insulated wire aging information. The same oven and vacuum facility was used for both groups to obtain equal test information. The long term tests were tested at a constant 230+5C.

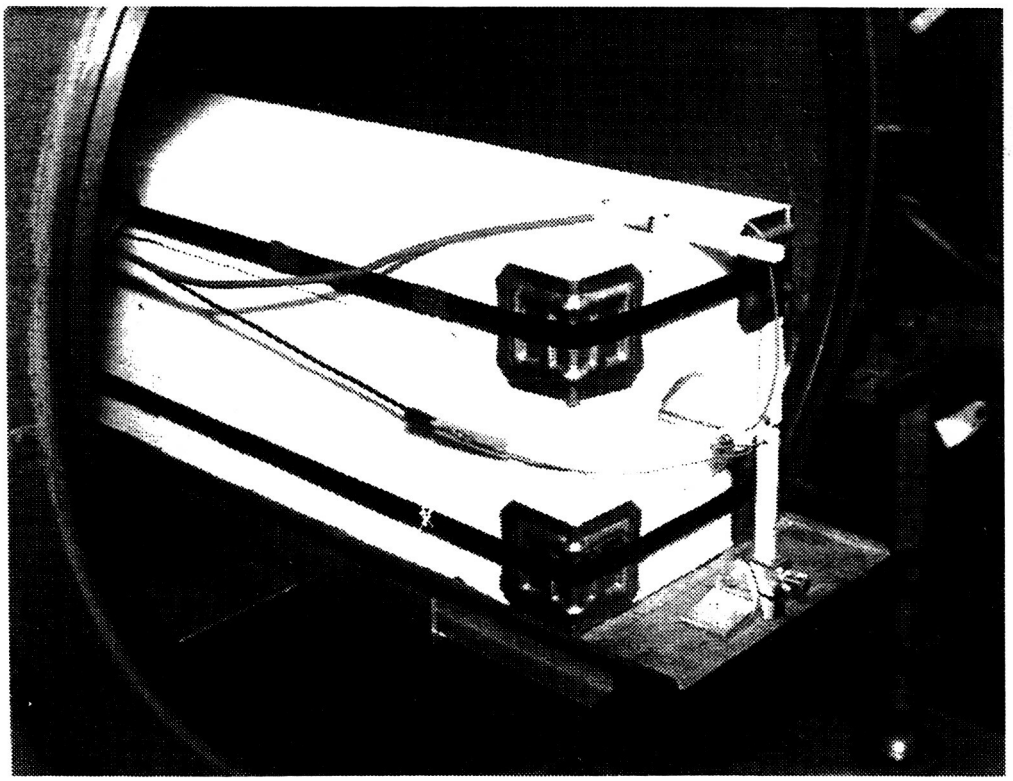
Glow Discharge Aging

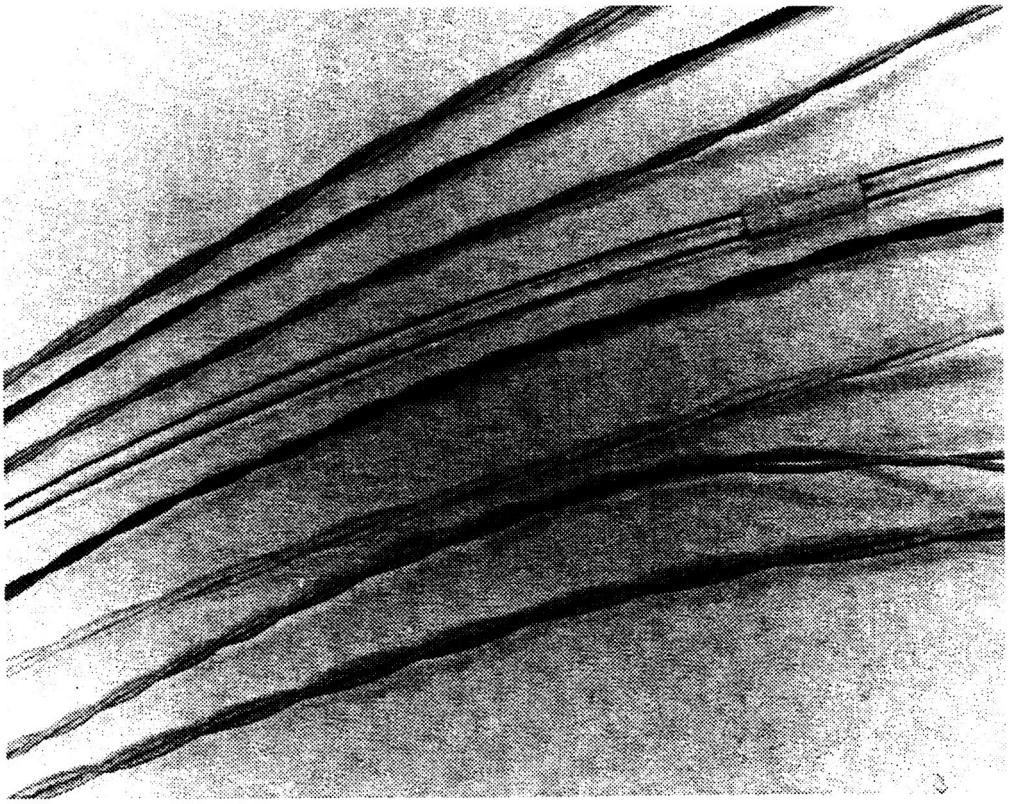
Same as temperature aging but with a continuous glow discharge added.











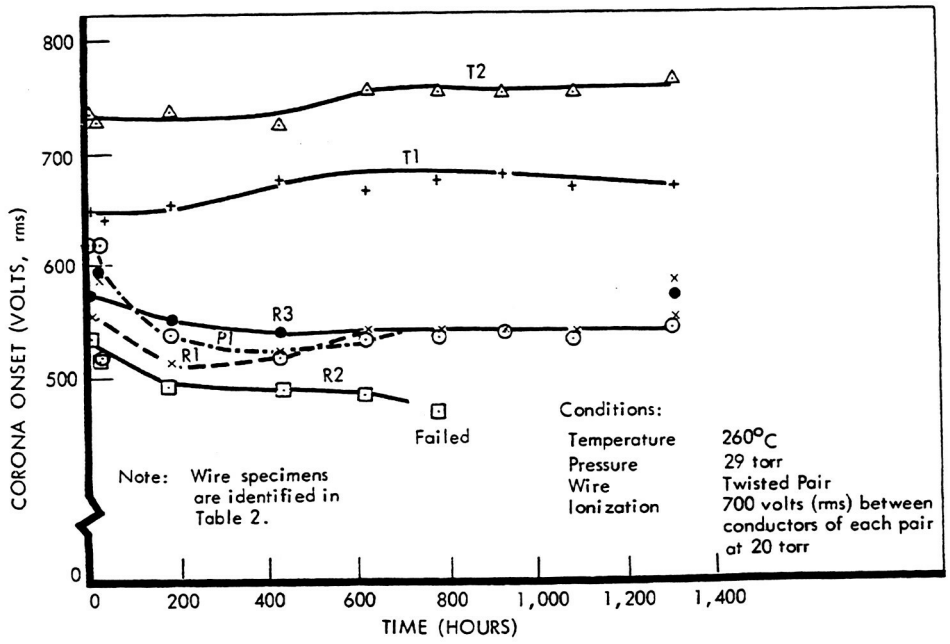


Figure 5: COV AS A FUNCTION OF TIME