



1

00:00:33,610 --> 00:00:41,130

This is the 200,000 pound thrust H-1 engine system 7055 disassembled into its major components

2

00:00:41,130 --> 00:00:45,370

prior to its extensive component, leak, and functional checks.

3

00:00:45,370 --> 00:00:51,510

This outboard engine, together with inboard engine number 4055, has successfully completed

4

00:00:51,510 --> 00:00:55,160

qualification testing during this quarter.

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00:00:55,160 --> 00:01:01,160

In this program, the H-1 engine system demonstrated that it meets all NASA requirements for safe

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00:01:01,160 --> 00:01:06,560

and satisfactory operation at the 200,000 pound thrust level.

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00:01:06,560 --> 00:01:10,570

The two engines were manufactured at Rocketdyne's Neosho, Missouri facility.

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00:01:10,570 --> 00:01:17,009

The outboard engine was tenth in the production line of the 200K model and the inboard engine

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00:01:17,009 --> 00:01:21,080

was the twelfth in its series.

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00:01:21,080 --> 00:01:24,640

Each engine completed three production acceptance tests at Neosho.

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00:01:24,640 --> 00:01:30,210

They were then shipped to Rocketdyne's propulsion field laboratory in California, where the

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00:01:30,210 --> 00:01:35,149

qualification test program was conducted.

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00:01:35,149 --> 00:01:42,930

Engine 4055 accumulated a total of 2,081 seconds of mainstage time in seventeen tests.

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00:01:42,930 --> 00:01:48,200

Engine 7055 accumulated 2,500 seconds in thirty four tests.

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00:01:48,200 --> 00:01:54,790

[Sound of Engines Firing] These tests ranged from routine operation to programmed malfunctions.

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00:01:54,790 --> 00:01:59,850

Ten duration tests were made on each engine to demonstrate engine life and performance

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00:01:59,850 --> 00:02:03,200

repeatability.

18

00:02:03,200 --> 00:02:07,619

Two tests were made during which the outboard engine was gimbaled through a half angle of

19

00:02:07,619 --> 00:02:15,380

three and one half degrees, the maximum angle being limited by the facility.

20

00:02:15,380 --> 00:02:20,420

The high and low temperature environmental tests were conducted on the Canyon 2 Test

21

00:02:20,420 --> 00:02:21,750

Stand.

22
00:02:21,750 --> 00:02:28,370
Internal temperatures of 130 degrees on the high side and zero degrees on the low were

23
00:02:28,370 --> 00:02:33,370
established by exposing the engine system to those temperatures for six hours prior

24
00:02:33,370 --> 00:02:37,950
to engine start.

25
00:02:37,950 --> 00:02:43,920
In the safety limits series, program malfunctions such as failure of valves to open or close

26
00:02:43,920 --> 00:02:49,840
and variations in pump inlet pressures and electrical system voltages, resulted in either

27
00:02:49,840 --> 00:02:53,880
safe engine shutdown or satisfactory operation.

28
00:02:53,880 --> 00:02:59,720
To demonstrate the dynamic stability of the combustion process of the H-1 engine, as shown

29
00:02:59,720 --> 00:03:05,080
here in high speed photography, a fifty grain bomb was detonated in a baffle compartment

30
00:03:05,080 --> 00:03:09,480
of the injector to induce combustion instability.

31
00:03:09,480 --> 00:03:18,110
Stable combustion was reestablished within twenty milliseconds of bomb detonation.

32
00:03:18,110 --> 00:03:24,060
Humidity tests on engine 4055 were conducted

in an environmental chamber at Rocketdyne's

33

00:03:24,060 --> 00:03:25,060

Canoga facility.

34

00:03:25,060 --> 00:03:31,220

The H-1 was subjected to three days of 130 degrees temperature and ninety-five percent

35

00:03:31,220 --> 00:03:33,120

relative humidity.

36

00:03:33,120 --> 00:03:39,269

The C-clamp, used here to hold a thermal couple in place, gives an indication of normal rusting

37

00:03:39,269 --> 00:03:41,910

that might be expected under these conditions.

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00:03:41,910 --> 00:03:46,910

The engine system itself, however, was virtually rust free.

39

00:03:46,910 --> 00:03:51,520

H-1 engine 7055 was subjected to a decontamination procedure.

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00:03:51,520 --> 00:03:54,640

It was rotated and held in various positions, then drained.

41

00:03:54,640 --> 00:04:01,120

The quantity of fluids remaining in the system at disassembly determine the effectiveness

42

00:04:01,120 --> 00:04:04,659

of the decontamination procedure.

43

00:04:04,659 --> 00:04:09,790

Static leakage tests were performed on the H-1 engine system prior to the start of the

44

00:04:09,790 --> 00:04:14,040

qualification program and upon completion of the test series.

45

00:04:14,040 --> 00:04:19,769

All fluid systems were tested for leakage while pressurized with GN2 at normal checkout

46

00:04:19,769 --> 00:04:23,430

pressures.

47

00:04:23,430 --> 00:04:28,760

Following engine disassembly, each component was given a leak and functional test to demonstrate

48

00:04:28,760 --> 00:04:32,450

the specified operating and functional characteristics.

49

00:04:32,450 --> 00:04:37,210

These tests were followed by a complete disassembly of each component for physical inspection

50

00:04:37,210 --> 00:04:39,460

and display.

51

00:04:39,460 --> 00:04:45,320

As the report period ended, component engineering evaluations were being prepared for incorporation

52

00:04:45,320 --> 00:04:49,669

into the final 200k H-1 engine qualification report.

53

00:04:49,669 --> 00:04:53,220

All requirements of the Qualification Program were successfully accomplished.

54

00:04:53,220 --> 00:04:54,770

[Sound of Engines Firing]

55

00:04:54,770 --> 00:04:58,940

The Reliability Demonstration Program was completed with testing of the qualification

56

00:04:58,940 --> 00:05:00,510

engines.

57

00:05:00,510 --> 00:05:09,390

Based on a demonstration sample of 333 pre-declared tests, a reliability of .9946 at fifty percent

58

00:05:09,390 --> 00:05:14,570

confidence was achieved.

59

00:05:14,570 --> 00:05:18,190

Completion of the component qualification program was also attained during this report

60

00:05:18,190 --> 00:05:19,190

period.

61

00:05:19,190 --> 00:05:24,550

The last of eight components to be tested in this program was the main LOX valve, which

62

00:05:24,550 --> 00:05:28,410

is observed during vibration tests at cryogenic temperatures.

63

00:05:28,410 --> 00:05:34,380

During this test series, the valve was vibrated in each of the three axes for a resonance

64

00:05:34,380 --> 00:05:35,690

search.

65
00:05:35,690 --> 00:05:42,450
This was followed by a ten minute sinusoidal sweep to 26Gs and a random dwell for five

66
00:05:42,450 --> 00:05:44,520
minutes.

67
00:05:44,520 --> 00:05:48,550
Tests on the LOX bellows seal were also completed during this report period.

68
00:05:48,550 --> 00:05:54,400
These tests were part of an overall program to evaluate the seal and its operating environment.

69
00:05:54,400 --> 00:05:59,660
The tests were initiated as a result of the failure of the seal to perform satisfactorily

70
00:05:59,660 --> 00:06:05,910
at the 200k level after having performed successfully at 188k.

71
00:06:05,910 --> 00:06:10,740
Since the failures experienced were fatigue failures, it was felt that a resonant condition

72
00:06:10,740 --> 00:06:16,280
between seal cavity environment and bellows natural frequency may have existed.

73
00:06:16,280 --> 00:06:22,210
Results of the vibration tests and seal cavity environment studies indicate that the failures

74
00:06:22,210 --> 00:06:24,490
are not due to resonant condition.

75
00:06:24,490 --> 00:06:27,490

Studies on this problem are continuing.

76

00:06:27,490 --> 00:06:30,600

[Sound of Engines Firing]

77

00:06:30,600 --> 00:06:35,240

Another significant program during this quarter was the limits test study.

78

00:06:35,240 --> 00:06:40,729

Essentially, this consisted of operating the 200,000 pound thrust H-1 engine system at

79

00:06:40,729 --> 00:06:44,860

thrust levels up to 230,000 pounds.

80

00:06:44,860 --> 00:06:49,430

Purpose was to study the upper operating limits of the H-1 engine.

81

00:06:49,430 --> 00:06:53,910

The majority of the components used were from the 200k production line.

82

00:06:53,910 --> 00:07:02,730

However, certain hardware known to be marginal at the high thrust levels were modified.

83

00:07:02,730 --> 00:07:09,740

Engine HL138 was instrumented with ninety-two string gauges and thirty-four thermal couples.

84

00:07:09,740 --> 00:07:16,520

It was hot fired for approximately 2,500 seconds and twenty-five starts.

85

00:07:16,520 --> 00:07:19,410

Evaluation of test data is in progress.

86

00:07:19,410 --> 00:07:23,919

Following final system and component leak and functional checks, the engine was disassembled

87

00:07:23,919 --> 00:07:26,520

for a thorough inspection.

88

00:07:26,520 --> 00:07:30,040

At the exit end of the thrust chamber, ripple patterns were noted.

89

00:07:30,040 --> 00:07:36,070

These were expected and are a result of thermal buckling at the higher thrust levels.

90

00:07:36,070 --> 00:07:40,539

Moderate damage was sustained in one area from a fragment of the fifty grain bomb used

91

00:07:40,539 --> 00:07:43,169

in the stability test.

92

00:07:43,169 --> 00:07:49,610

In the combustion chamber, a number of dents and two pinhole leaks were observed.

93

00:07:49,610 --> 00:07:54,540

These also are believed to have been caused by bomb fragments.

94

00:07:54,540 --> 00:08:00,190

The injector used in the limits test program was of standard 200k design, but modified

95

00:08:00,190 --> 00:08:05,770

to enlarge the orifices on the oxidizer side by thirteen percent and on the fuel side by

96

00:08:05,770 --> 00:08:08,060

ten percent.

97
00:08:08,060 --> 00:08:13,430
This allowed greater propellant flow with
a minimum increase of the pump requirements.

98
00:08:13,430 --> 00:08:19,149
The whole was machined for installation of
the fifty grain bomb.

99
00:08:19,149 --> 00:08:25,190
The turbopump was found to be in excellent
condition following the limits test program.

100
00:08:25,190 --> 00:08:29,960
The A pinion,

101
00:08:29,960 --> 00:08:34,610
the intermediate gear,

102
00:08:34,610 --> 00:08:41,979
and the main shaft spline of the gear case
showed little wear on the contacting surfaces.

103
00:08:41,979 --> 00:08:47,200
Bearings numbers one through six showed no
excessive axial load resulting from increased

104
00:08:47,200 --> 00:08:48,580
power operation.

105
00:08:48,580 --> 00:08:54,709
Also, there was very little evidence of outer
race outboard shoulder wear.

106
00:08:54,709 --> 00:08:59,220
Bearing number seven of the turbine assembly
was in excellent condition.

107
00:08:59,220 --> 00:09:04,850

Bearing number eight, also of the turbine assembly, was in good condition.

108

00:09:04,850 --> 00:09:09,570

Turbine wheels were binocular inspected, and there was no evidence of erosion or cracks

109

00:09:09,570 --> 00:09:12,520

on the turbine blades.

110

00:09:12,520 --> 00:09:16,820

The operating parts of the main LOX valve showed no unusual wear.

111

00:09:16,820 --> 00:09:24,000

The wear band on the gate drive shaft is normal for thrust levels sustained by this engine.

112

00:09:24,000 --> 00:09:30,500

The bearing race of both the drive shaft and of the idler shaft showed no evidence of gulling.

113

00:09:30,500 --> 00:09:35,829

The rollers were in good conditioned showed no signs of end wear.

114

00:09:35,829 --> 00:09:40,730

An improvement was made in the fit-up prior to weld of the bellows to the line of the

115

00:09:40,730 --> 00:09:42,660

turbine exhaust hood.

116

00:09:42,660 --> 00:09:50,110

Posttest inspection showed no cracks as a result of engine operation as high as 230k.

117

00:09:50,110 --> 00:09:55,940

The gas generator combustor body was fabricated from Hastelloy C instead of 347 steel.

118

00:09:55,940 --> 00:10:02,459

In addition, it employed an extra stud to permit more even distribution of flange and

119

00:10:02,459 --> 00:10:04,860

seal loading.

120

00:10:04,860 --> 00:10:10,040

Inspection showed the unit to be in excellent condition following the test program.

121

00:10:10,040 --> 00:10:15,170

The gas generator injector was a standard model with increased orifice sizes to provide

122

00:10:15,170 --> 00:10:20,399

for more propellant flow with a minimum increase in feed pressure.

123

00:10:20,399 --> 00:10:24,830

As noted by the carbon area, the condition of the injector was typical of those tested

124

00:10:24,830 --> 00:10:26,100

at 200k.

125

00:10:26,100 --> 00:10:33,870

In general, the limits test engine, HL138, exhibited very satisfactory performance and

126

00:10:33,870 --> 00:10:38,579

provided data needed to calculate stress margins at the high thrust levels.

127

00:10:38,579 --> 00:10:45,019

A second limits test engine, HL139, is currently undergoing tests.

128

00:10:45,019 --> 00:10:50,519

This engine is instrumented with thirteen accelerometers to provide vibration data on

129

00:10:50,519 --> 00:10:54,100

critical components.

130

00:10:54,100 --> 00:10:59,560

The program to evaluate an experimental thick walled tube forming process continued during

131

00:10:59,560 --> 00:11:00,720

this quarter.

132

00:11:00,720 --> 00:11:05,959

In the conventional method, the dye in which tubes are formed, is machined from a steel

133

00:11:05,959 --> 00:11:07,399

plate.

134

00:11:07,399 --> 00:11:13,110

This method ensures a high degree of integrity but requires a long lead time in fabrication

135

00:11:13,110 --> 00:11:17,709

before a new tube design can be evaluated.

136

00:11:17,709 --> 00:11:22,770

In the new process, a moderately wide trench is formed through rough machining of the metal

137

00:11:22,770 --> 00:11:23,770

plate.

138

00:11:23,770 --> 00:11:29,240

The contour is approximately that of the desired configuration, which in this case is an experimental

139

00:11:29,240 --> 00:11:31,320

thick walled round tube.

140

00:11:31,320 --> 00:11:35,420

The cavity is filled with an epoxy resin.

141

00:11:35,420 --> 00:11:40,079

This filler cures and hardens at room temperature in approximately twelve hours.

142

00:11:40,079 --> 00:11:44,930

It will withstand 2,500 psi compressive stress.

143

00:11:44,930 --> 00:11:50,589

The mold in which the tube is formed can be made either by pouring the epoxy around a

144

00:11:50,589 --> 00:11:58,160

master tube set in place or by pressing the tube into the mixture prior to hardening.

145

00:11:58,160 --> 00:12:04,790

Initial evaluation was concerned with dimensional integrity of the dye, precision repeatability,

146

00:12:04,790 --> 00:12:07,779

and durability of the mold.

147

00:12:07,779 --> 00:12:10,079

Integrity and repeatability were very satisfactory.

148

00:12:10,079 --> 00:12:16,120

Durability, however, was not satisfactory as wear was noted at the dye throat after

149

00:12:16,120 --> 00:12:20,019

forming of the first 300 tubes.

150

00:12:20,019 --> 00:12:24,870

The first thrust chamber to be fabricated from tubes formed by this process had completed

151

00:12:24,870 --> 00:12:27,620

both furnace brace cycles as the quarter ended.

152

00:12:27,620 --> 00:12:31,680

It was then shipped to Neosho for completion.

153

00:12:31,680 --> 00:12:35,579

Durability of the dye will continue to be evaluated during forming of tubes for a second

154

00:12:35,579 --> 00:12:36,749

thrust chamber.

155

00:12:36,749 --> 00:12:40,259

[Sound of Engines Firing]

156

00:12:40,259 --> 00:12:43,029

Accomplishments during this quarter were significant.

157

00:12:43,029 --> 00:12:49,269

Completion of the 200k Engine Qualification Program, completion of the Component Qualification

158

00:12:49,269 --> 00:12:56,940

Program, demonstration of ninety-nine percent reliability at fifty percent confidence, and