Powerplant Fire Testing

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Transport Canada Delegates Conference

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Powerplant Fire Testing

Objective:

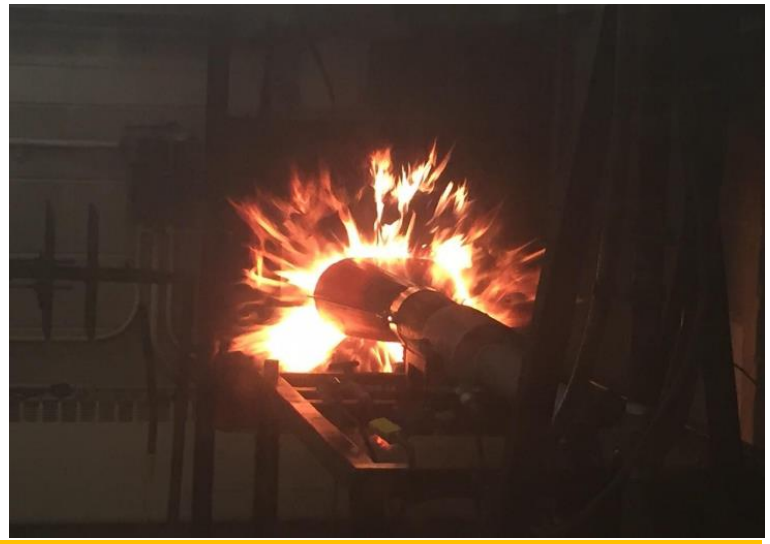
Provide awareness of

- Concerns on PP fire test guidance
- The activity currently on-going to define a single authority recognised guidance material (an SAE ARP or AS)
- Task Group Findings to date,
  - considerations for near future fire tests

Powerplant Fire Testing

Agenda

- Fire Test Guidance material
  - multiple sources w/ conflicting guidance
- Fire Test Requirements, SAE A-22 activities & status
  - Common Definitions
  - Burner
  - Thermocouples
  - Heat Flux measurement
  - Specimen: dimensions, mounting, loads, vibration
  - Boundary Conditions
  - Pass-Fail Criteria
- Learnings to date



This activity is limited to fire testing.

It is not attempting to address PPLT fire protection design criteria, such as detection, containment, flammable fluids,…

Powerplant Fire Testing

Powerplant Fire Test Requirements working Group,

now under SAE A-22 'Fire Protection and Flammability Testing Committee'

- The initial task working group had identified a list of > 50 concerns within AC 20-135 that industry members felt needed to be addressed.
- The list was reduced to a 'top ten' list to facilitate focus and priority.
  - Note the 'top ten' covered the majority of the identified concerns
- The intent was to update AC20-135
  - Address the identified issues
  - Add the Next Gen (sonic burner) as an accepted alternative / preferred burner
- FAA legal stated that an SAE committee was needed in order to ensure all voices are heard and to allow for more formal engagement between industry and regulators.
  - The goal is to have the FAA consider the SAE document as the accepted standard, recognised by reference in a revision of AC20-135
- The above would address the concern regarding the number of current specification documents, several that replicate each other, others with differences, leading to confusion and inconsistent test practices

Greater than 50 specific concerns were identified by industry

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FIRE TEST GUIDANCE MATERIAL

FAA / TCCA Powerplant Installation Certification Standard

1. **AC20-135** (Change 1) **POWERPLANT INSTALLATION AND PROPULSION SYSTEM COMPONENT FIRE PROTECTION TEST METHODS, STANDARDS, AND CRITERIA**
   - FAA POWERPLANT REPORT #3A STANDARD FIRE TEST APPARATUS & PROCEDURE

EASA Powerplant Installation Certification Standard

2. **ISO 2685** **TEST PROCEDURE – RESISTANCE TO FIRE IN DESIGNATED FIRE ZONES**

FAA / TCCA Engine Certification Standard

3. **AC 33.17-1A** **ENGINE FIRE PROTECTION**

Other References

4. **DO160 F Section 26** **ENVIRONMENTAL TESTING – FIRE, FLAMMABILITY**
5. **FAA HANDBOOK** **(DOT/FAA/AR-00/12)**
   - Chapter 11 Powerplant Hose Assemblies Test
   - Chapter 12 Powerplant Fire Penetration Test
   - Chapter 13 Test for Electrical Connectors Used in Firewalls
   - Chapter 14 Test for Electrical Wire Used in Designated Fire Zones
6. **SAE AS1055** **FIRE TESTING OF FLEXIBLE HOSE, TUBE ASSEMBLIES**
7. **SAE AS 4273** **FIRE TESTING OF FLUID HANDLING COMPONENTS**

Many test references with conflicting guidance

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Powerplant Fire Test Requirements working Group,

now under SAE A-22 'Fire Protection and Flammability Testing Committee'

- Top concerns raised by industry related to PPLT fire testing (not in order of priority)
  - ***Harmonize all Specifications / References, into an accepted standard***
  - **Burner repeatability**
  - **Flame Temperature**
    - **Thermocoupless (size, type, number)**
  - **Flame Calibration Method**
  - **Definitions; Fireproof; Fire resistant; Heat Flux: etc**
  - **Test Pass/Fail Criteria, including TSO hose assemblies** **(hoses qualified under a Technical Standard Order Authorization)**
  - **Post-Test Burning, Backside Ignition**
  - **Environment / Operating conditions**
  - **Test setup; Panel Size**
  - **Materials; fireproof, resistant by definition**

Greater than 50 specific industry concerns that the team prioritized & combined then separated into subgroup activities

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A-22 Sub groups

Group A:	Group B:	Group C:
• Burner/Flame Temperature • Flame Calibration Method • TC's (size, type, number) • Environment/Operating Conditions	• Post-Test Burning/Backside Ignition • Test Pass/Fail Criteria	• Fireproof/Fire-resistant Definition • Panel Size

- Thermocouple Calibration Sub-Group of Group A
- New Group D formed; Standardizing Applicant **Approach for Defining Test Article Boundary Conditions** for 5 Minute and 15 Minute Powerplant Fire Tests

Active support by FAA, EASA, TCCA, and some participation from CAAC & ANAC

TEST TEMPERATURE CRITERIA

AC 20-135 defines Fire Proof as

The capability of a component to withstand **2000F flame (+-150F)** for 15 minutes minimum

The FAA Certification Office (& TCCA) interpretation of 2000F (per AC33.17-1)

2000F minimum average with no thermocouple below 1850F during calibration

With the above interpretation of the required minimum temperature the fire test severity has been upped with, in many cases, unanticipated redesigns being required

Consistent Fire definitions accepted by all authorities in all documents and formal guidance on interpretation of the formal definitions (in CS-DEF & FAR Part 1) is a group task

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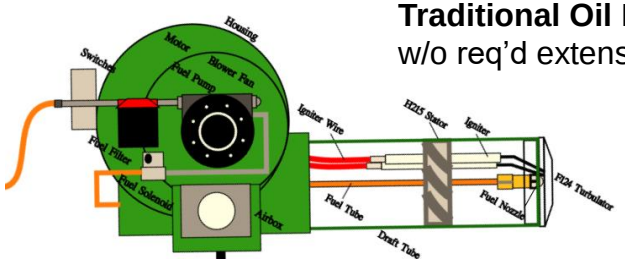
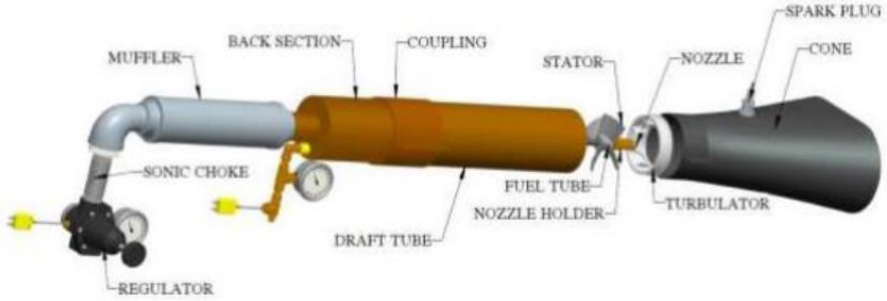
BURNERS

- None of the FAA defined accepted burners are manufactured today (oil burners from the 70's) , though most test houses are using similar Park or Carlin burners to those listed in FAA Powerplant report #3A
- FAA 'accepted burners (per report #3A)' would NOT meet todays test criteria, without turning up the fuel flow / air flow to meet minimum flame temperature requirements
- FAA are developing a ' Next Gen' aka the 'Sonic' burner that will be clearly defined both in construction and operation with the goal that no pre test calibration will be necessary
- FAA have indicated that they will set the Next gen burner characteristics to replicate the agreed working group (A-22) burner standards.



Traditional Oil Burner,
w/o req'd extension



Next Gen Burner

Propane burners no longer accepted by FAA for certification fire testing per AC20-135 Change 1 (15 May 2018)

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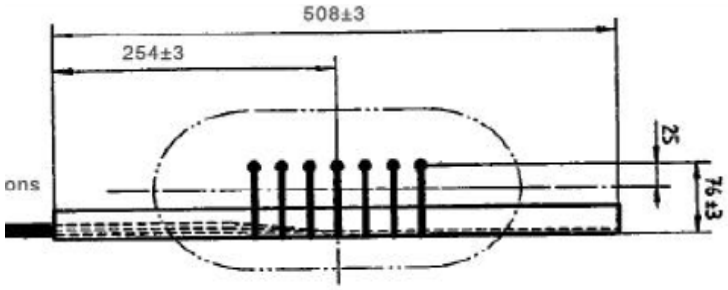
THERMOCOUPLES

- Principal concern has been the requirement for a 2000°F min avg across all seven t/c's
- No. of t/c's for calibration has varied throughout regulatory history, currently the outside t/c's driving up test flame heat
- Aging of t/c's now a known concern (lower reading), particularly with smaller t/c's



Liquid Fuel Burner – Thermocouple Positions
(burner shown in horizontal position)

- Smaller t/c's are considered more representative as they react quicker and an oil flame is not steady
  - Early data indicates ~ **100°F higher** reading on new 1/16" vs new 1/8" t/c's
- SAE-A22 sub group is undertaking a round robin of various t/c's to a support t/c recommendation for the new standard
  - Very preliminary data provided at A-22 meeting 01-02 November

Consider using new 1/16'' Cr-Al, exposed tip, Type K, to a recognized for certification fire tests until an agreed t/c is defined, to reduce flame intensity, yet showing >2000F min avg

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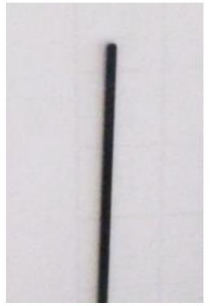
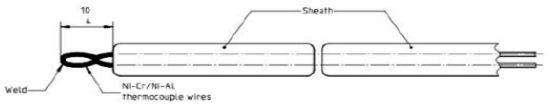
THERMOCOUPLES

1/8 inch (3mm) OD
Fully sheathed

1/8 inch (3mm) OD
Exposed Junction
(10mm)



1/16 inch (1.6mm) OD
Fully sheathed

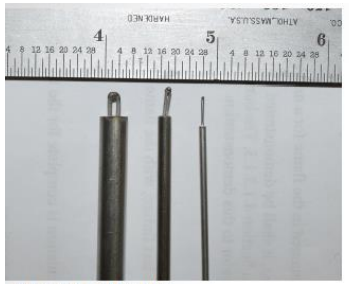


NOTES

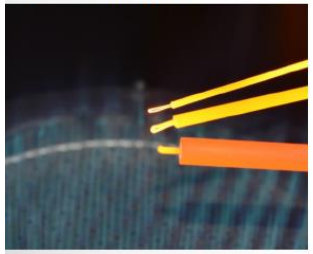
1 The diameter of the thermocouple wire shall be between 0,6 mm and 1 mm.
2 If a metal sheath is used, the maximum diameter shall not exceed 3 mm.
3 The thermocouple shall be unshielded and non-aspirated.

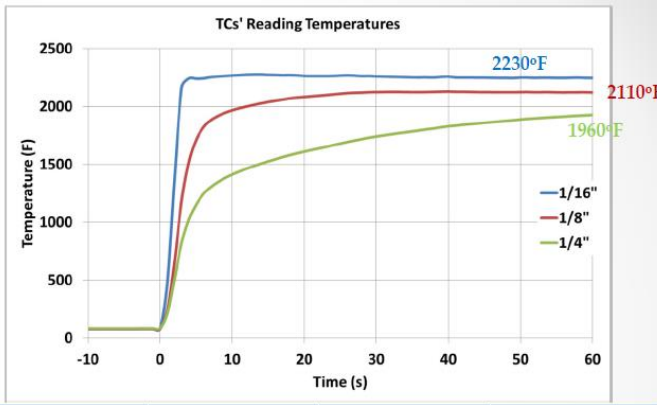
Figure B.1 — Details of thermocouple

Extract from FAA & SAE A-22 presentation material



LEFT to RIGHT:
1/4″ SS sheath TC;
1/8″ SS sheath TC;
1/16″ SS sheath TC





	1/16″ TC	1/8″ TC	1/4″ TC
wire size	0.012 inch	0.020 inch	0.039 inch
bead size	0.020 inch	0.033 inch	0.064 inch
AWG	28	24	19

- The smaller TC could reach higher reading temperature and have faster response time than the bigger TC in the identical fire environment.

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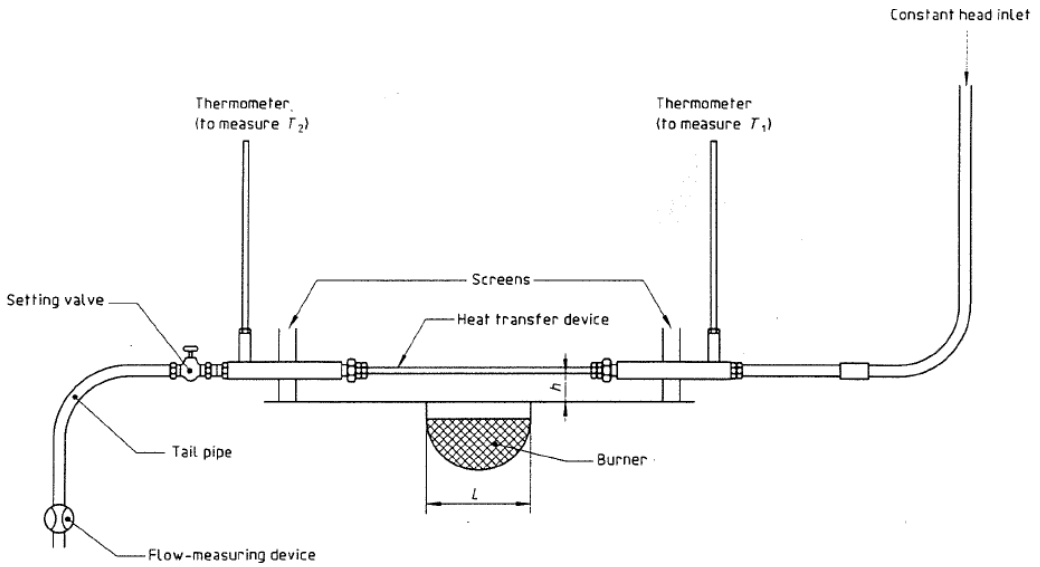
FLAME HEAT FLUX CALIBRATION

- Common method is use of water thru a copper tube
  - Inconsistent build & calibration instructions between standards
- Variability & sensitivity from
  - water temperature, & flow
  - shielding of flame,
  - cleaning of the tube,
  - warm up times
- May not pickup cold /hot spots from flame variances
- Use of calorimeters accepted but typically only measure a single central point
  - Consider 3 points though not a req'ment
- Proposal of plate measurement methods for structure under review



Present recommendation use Copper tube, start cal. Clean tube before every cal.

Commence cal once 4500BTU/hr is reached, followed by the req'd 3 minute heat flux calibration

SPECIMEN's & SET-UP

- Use a horizontal burner unless test criteria demands an alternative position, to avoid debris getting into the burner
  - Any burner position, not horizontal or vertical to be well defined in test plan for Authority acceptance. Centre of heat (burner calibration) may be req'd
- Size of specimen not well defined nor have labs or industry been consistent
- Ensure test specimen fixture allows the required thermal expansion so that the test apparatus does not cause a test failure, by opening up gaps, or loading the specimen.
- Ensure thermal mass surrounding the specimen is representative to assist in taking away heat if relevant
- Consider maximizing the size of the test specimen to minimize fixture effects

Test fixtures may influence test results and must be considered in the test plan & specimen set-up

FIRE PROOF & FIRE RESISTANT MATERIALS

- Once team has an agreed definition for fire proof & fire resistant, it can then define accepted materials by definition.
  - Definition to be consistent with FAA Part 1 & EASA CS-Def to avoid rule changes. This activity wants to limit to changes to standards / accepted guidance
  - May be limited to Steel for fire proof & Aluminum for fire resistant, in a size appropriate for the function
- Aluminum, is this fire resistant by definition?
  - Tests with 2000F min average burners generally burnthrough 1/8 in plate in ~ 2.5 minutes (+/- > 1 minute)
  - Many tests of non-metallic materials do a back to back to show fire resistance yet unclear as to Aluminums' capability
- Clarity needed as to when an actual test is required to the 5 or 15 minute standard vs when a comparative test is needed, or accepted by material selection
  - AC20-135 (for P23) indicates: 0.04” aluminum panel with a 80 Kt minimum scrubbing airflow over the back side has been shown to maintain integrity when subjected to 2000F for 15 minutes.

Task Team looking for a referee panel that may be used to compare burners and be able to set the Next Gen burner to be the same intensity as the current fluid burners

PASS – FAIL CRITERIA

For consideration as follows, though will change depending on specific test specimen purpose and component type (seal, structure, hose, tank,…)

- No flame burn through from fire side to non-fire side.
- No backside burning of the parts on the non-fire side, unless fire / out gassing can be shown non-hazardous
- There shall be minimal residual burning
  - It is acceptable to have some low intensity burning (wicking flame) for a short time that self extinguishes. Short time is in the order of 30 seconds, though longer may be justified on a case by case basis
- There shall be no leakage that would measurably add to the fire severity
  - There shall be no leakage to support a flame after the burner has been removed. Wetting or droplets (non running leak) that will not support a continued fire are acceptable
  - Fluid tank housing burn through, melting or burning is accepted as long as over-all structure is maintained
- Component must be shown to perform intended function under fire conditions, some examples are:
  - SOVs in DFZ to function for 5 min and remain closed for test duration (total 15 min), Isolation valves to fail closed and remain closed for test, Controls to fail sane / safe
- Ancillary equipment not under test do not need to meet the acceptance criteria (harnesses, tubing,..)
- Component out gassing could be a concern, depending on the out-gas composition and the component location (danger to crew & passengers)

Pass-fail criteria not yet agreed & will need to be general, the test plan is vehicle to define

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OPERATIONAL SENARIO's

- Structural (and seals) loads & pressures
  - Guidance on loads for units under test if loaded e.g mounts, latch & hinges
    - 70 % limit loads for 5 minutes, get home loads remaining 10 minutes ??
  - FAA currently require seals w/ >0.5 psi to have pressure across them under test
- Fluid / component pressure
  - Guidance on flow and pressure
    - 1st 5 minutes, remaining 10 ??
    - No flow condition for hoses now introduced into SAE AS1055
- Vibration
  - Criteria when vibration required
    - vibe intent not to simulate engine / aircraft but to shed burnt debris
  - Vibration is an input, setup & maintained on rig fixture, not on value the component while under test
  - Levels defined for structure, hoses, fluid equipment unlikely to change per FAA handbook & ISO
- Ground vs Flight conditions, is combining into a single test possible

New Group D formed; Standardizing Applicant **Approach for Defining Test Article Boundary Conditions** for 5 Minute and 15 Minute Powerplant Fire Tests

Powerplant Fire Testing

Industry Suggestions to FAA / Authorities (in work)

- **One standard for all PPLT fire testing**
  - SAE standard will supersede AC20-135, AC33-17, ISO2685
- **Standard / consistent test equipment & methods**
  - Fluid Burner model should not be an issue
    - as long as extension is per current standards,
    - temperature & heat flux meet requirements,
    - mapping to confirm no hot or cold spots after any physical change or adjustment
- **Consistent definition for fire proof & fire resistant**
  - test or equiv. to Aluminum
  - Recognised fire proof materials
- **Improve Pass-fail guidance**
- **Standardizing approach for defining test article boundary conditions**
  - for both fire resistant/5 Minute and fire proof /15 Minute powerplant fire tests

Authorities have been very supportive of the activity. They want a consistent better defined standard as well.

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Timeline for new standard

- Technical Report Document Draft(s) complete: May 2018 – May 2019
  - Including regulatory agencies' comments & inputs
  - Including other Industry Specification focals' comments & inputs
- Document(s) for final SAE balloting approval: June 2019 to December 2019
- SAE document(s) publication: January - May 2020
- FAA Revision of AC20-135 to reflect SAE document(s): May 2020 – December 2020

SAE A-22 committee will coordinate with regulatory agencies (FAA, EASA, TCCA + ANAC, CAAC) and other Industry Specification (ISO, RTCA) focals, for concurrence and standardization

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If you need to run a test, Task Group Learnings until new standard is published

- Recognise that a **fire test burner flame is not a steady temperature**
- Use new small (1/16th in.) t/c's as they respond quicker & hence read higher
  - Stabilization (break-in) and degradation over time remains under investigation
- Heat flux measurement device, use within spec: coolest water, clean tube before every calibration, start calibration as soon as required heat flux is reached
- Determine center of highest heat (nominal 1 in. above center on a horizontal burner) by mapping the burner temperature pattern so that specimen & above calibrations are at the center of heat
  - Note this will need to be agreed with TCCA as most current guidance material uses 1 in. above
- Higher airflows from the burner settings result in cooler heat flux, do not open up air flow more than necessary.
- Clearly defined pass- fail criteria in a test plan will help reduce post-test discussion

Ensure test plan takes latest learnings from the task team, within the bounds of the current certification standards

Q&A

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