JARĐ25
Comment/Response Document
NPA 25J-246
APU Instruments

Introduction and Justification

Most, if not all, state of the art auxiliary power unit installations are designed for unattended operation on the ground. They are therefore protected by a completely automatic control system incorporating automatic shut down in case of exceedance of parameter limitations which should affect health and/or integrity of the unit.

For operation in flight as an essential source of electrical power it may be left to the discretion of the pilot to delay shut-down after exceeding of certain parameter limitations which only affect mechanical health but not unit integrity, e.g. gas temperature, oil pressure and oil temperature. For such parameters an indication or warning means should then be provided on the flight deck to initiate manual shut-down.

In view of the almost immediate effect on unit integrity of significantly exceeding rotor speed limitation automatic shut-down after such fault is usually provided for also in flight.

Furthermore the presence of indicators cannot extend safe running time after unit failure in above cases.

Therefore if completely automatic monitoring and protection systems are provided a tachometer and gas temperature indicator are not required to ensure safe unit operation. It is evident that compliance with JAR–APU and JAR 25A 901(c) must be shown for the automatic monitoring, protection and shut-down systems as well as with JAR 25A 903(d)(1) and JAR 25A 1549.

1 Comments were received from:

CAA UK
Aerospace Industries Association USA.

2 Background

The referenced NPA proposed a clarification of the requirements for instruments (and indicators) for Essential APU installations.

3 CAA Comment

See Attachment 1.

4 Sponsor's Reply

4.1 The intent of the comment is understood to be that, for Essential APUs, a pre-flight confirmation of satisfactory APU operation (with adequate performance and health margins) should be known by the flight crew.

4.2 In practice two cases arise:

(i) Where the APU is required to be operating throughout the flight to provide an alternative Essential service to an (already) failed aircraft component or system, or

(ii) Where the APU is to be available to provide an alternative Essential service in the event that an aircraft system fails during the flight.

4.3 In the first case, the APU will be started on the ground prior to flight and will run satisfactorily unless any of the automatic shut-down criteria are met. It is agreed that at this stage the extent of performance and health margins may not be known.

During the flight, if any of these margins are eroded, the pilot will receive a caution/warning and will be able to decide whether to shut the APU down (losing the APU driven Essential service) or to keep the APU running and risk APU damage. ***NOTE:*** *An APU even in these circumstances will not be the sole provider of the Essential service. To lose this service entirely on a single flight will require both the APU and the other service provider (e.g. engine driven generator) to fail i.e. a double failure.*

4.4 In the second case, where the APU may not be started prior to the flight, three failures would be required to totally lose the Essential service which is (partly) being provided by the APU.

4.5 In general, where an APU provides an Essential service, aircraft safety does not depend solely on this provision; the system design is required to provide sufficient redundancy so that total loss of the service is an acceptably low probability.

4.6 Even when APU indications are provided, it is not necessarily the case that the performance margins are known at the design performance condition. (See Attachment 3.)

4.7 For these reasons, the CAA comment is not supported.

5 Aerospace Industries Association (AIA) Comment

See Attachment 2.

6 Sponsor's Reply

6.1 AIAs first comment is correct (c)(6) should be (c)(8). The NPA will be amended accordingly.

6.2 Regarding AIAs second comment, in fact the requirement has not changed; only the numbering has been revised for continuity. The intention of these requirements is to provide a similar standard of indication as that provided for main engines. No revision of the NPA is proposed to cover this comment.

Attachment 1

CAA COMMENT ON NPA 25J-246 APU INSTRUMENTS

The CAA does not disagree with the intent of this NPA. However in evaluating the need for the instruments detailed in 25B.1305, it must be remembered that an 'essential' APU provides a service which is necessary for the despatch of the aircraft to maintain safe aircraft operation (as defined in JAR–APU).

Therefore, prior to each flight for which the availability of the APU's service is essential, it would seem necessary to establish that the APU has adequate remaining margins below its limits of turbine gas temperature and rotor speed(s) and, possibly, oil pressure/temperature for the purposes of that particular flight. Consideration should therefore be given to how this can be achieved without the provision of the appropriate parameter indicators. Pre-flight confirmation of APU health is even more necessary when the 'essential' service provided by the APU is associated with ETOPS/EROPS flights. Provision should also be made for the health of an 'essential' APU to be confirmed during flights under ETOPS/EROPS rules, before entering the ETOPS/EROPS portions of such flights.

The above objectives could be met by making the following changes to this NPA:–

(i) Extend the NPA's proposed text at the second line of paragraph (a) of JAR 25B 1305, to read as '. . . . . are not necessary to ensure safe operation of the unit and are not required for compliance with paragraph (b)(3) below:'

(ii) Add a new paragraph (b)(3) to JAR 25B 1305, to read as:–

(b) (1)

(2)

'(3) Any instruments necessary for determining, prior to take-off and during flight, that the APU is capable of performing its intended essential functions.'

Attachment 2

AEROSPACE INDUSTRIES ASSOCIATIONS COMMENTS

JAA NPA 25J-246; APU Instruments

1 Under proposal item (4), the reference to sub-paragraph (c)(6) should be (c)(8).

2 Under proposed paragraph (b)(2) of JAS 25B 1305, the benefit of having 'indication of proper functioning' is not clear. If the heater used to prevent ice clogging of the fuel system components should fail, there is no corrective action that the crew can take. The indication, therefore, serves only as a pre-warning of a potential APU shutdown that will occur (or not occur) independent of indication. The DC9/MD80 aircraft series has accumulated 50 million hours of operation with an APU fuel heating system having no malfunction indication and no problems are known to exist.

It is recommended that this proposed requirement be reviewed prior to incorporation.

Attachment 3

DISCUSSION: Is there a need for a regular check on performance deterioration for an essential APU?

Difference between engine- and APU rating

Whereas the extent of derating an ATTCS/ATTPS rated engine during normal take-off is closely controlled and therefore maximum T.G.T. figures for normal T.O. can be specified in the flight manual, (sometimes as a function of ambient conditions) which ensure a satisfactory margin for rated T.O. and also for an engine operated at flexible (derated) T.O. thrust or -power a regular check at full T.O. power can be instructed to ensure satisfactory margins, this is not practical for an APU. The bleed air- and shaft power off take during ground operation is subject to large variations depending on such factors as:

– *For bleed air off take*

  (1) propulsion engines simultaneously supply bleed air or not

  (2) ECS mode i.e. normal or economy; selected cabin temp. full hot, full cold or in between

  (3) engine a.i. selected ON or OFF

  (4) for certain aircraft: wing- and or empennage leading edge heating selected ON or OFF.

– *For shaft power off take: the electrical or where applicable hydraulic services selected ON which may be shared between main engine driven generators and APU-generator.*

– *The APU-control system which may for hot end life preservation reasons have a software based throttling function varying with ambient temperature which prevents selection of a meaningful max. rated bleed load at moderate ambient temperatures.*

Furthermore it is questionable if checking of a rated bleed load TGT (usually the max. load on the ground) is meaningful for the loading condition at max. cruise altitude in the 'essential' (generator-drive) role. Especially for APU's with a bleed type compressor the max. load on the ground occurs in a totally different part of the engine working line than the shaft load condition at altitude.

Moreover this load is a dynamic one, i.e. the APU has to provide the power for fault clearing of an electrical fault condition in the circuit of the maximum individual power consumer (usually windshield heating or another heating element) for the duration necessary to trip its circuit breaker. The ultimate load is created by a line to line short between two of the three phases of the generator bus, being supplied by the APU driven generator, for the duration necessary to enable the generator control and protection system to disconnect the generator from the bus. Not all 'essential' APUs are able to support this load.

During both fault conditions, lasting only a few seconds, the APU fuel control system will attempt to maintain governed speed and the APU-TGT may rise to the red line limit, whilst r.p.m. is dropping. The line to line fault causes a load of approx 150% of rated. Some APU's are automatically protected by the generator underspeed protection, disconnecting the generator from the bus when the r.p.m. drops below 95% rated speed. The APU subsequently stabilizes at idle.

Failure effects

When operating in the essential role, i.e. the APU driving a generator at departure under MMEL with an inoperative main engine driven generator, there is at least one operative main engine driven generator available. Cat III landing is no longer allowed but all other electrical services remain available. Hence loss of this APU driven generator is only a minor effect as long as the main engine driven generator remains operative. When operating in this single generator mode most twin-engine generator systems will automatically shed all non-essential load such as gallies, ovens, coffee-makers etc.

The maximum remaining essential load usually is within 60% of the rated continuous load for a single generator hence it can be easily supported if no further fault occurs. A subsequent failure of the remaining

generator within the same flight has a very low probability and would cause only a minor to major effect as safe operation without normal electrical power must be shown (JAR 25.1351).

In this respect there is a large difference between loss of one propulsion engine during take-off in combination with excessive deterioration of the live engine (probability ≈ 10^{-7} to 10^{-8} with hazardous to catastrophic effect) and loss of all normal AC-power due to a combination of

(a) an MMEL departure with a main engine generator inoperative,

(b) a specific bus fault in the generator system driven by the APU and

(c) ambient conditions at the instant of failure and/or excessive deterioration such that the APU cannot deliver the power needed to clear this fault.

(Probability ≈ 10^{-9} to 10^{-10}, minor to major effect).

CMR

As a cockpit check during or pre-flight is not practical, introduction of a CMR for a maintenance check under controlled conditions might be considered, similar to an engine ground run at T.O. conditions.

However, for the airlines it is not acceptable to introduce a CMR for a routine APU performance deterioration check, requiring a specific and well-controlled APU loading mode, which may only be possible under certain ambient conditions, to avoid a failure condition with only a minor to major effect.

Some airlines keep a loose check on APU deterioration by trend analysis of stabilized APU-idle TGT on a voluntary basis.

Oil temperature

Reduction of oil temperature margins is usually caused by oil cooler contamination, which should be controlled by periodic maintenance if found to be a problem.

Exceeding oil temperature limits temporarily when operating in the essential role may be judged by the pilot to be an option if the added risk of operating without AC power is not considered acceptable. Even if no gauge is provided a high oil temperature alert is usually presented.

Conclusion

In view of the above it is not considered justified to introduce a new requirement in JAR 25B 1305 as proposed by commenter.