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ADVISORY CIRCULAR

DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

SUBJECT: GUIDELINES ON THE MARKING OF POWERPLANT INSTRUMENTS

1. PURPOSE. This circular provides guidelines on the marking of aircraft powerplant instruments. These guidelines offer acceptable, but not exclusive, methods of compliance with the powerplant instrument color marking requirements.
2. REFERENCE. Federal Aviation Regulations, Parts 23, 25, 27, and 29 with section numbers 1543, 1549, and 1551 respectively.
3. GENERAL. Powerplant instrument range markings are intended to indicate to the pilot, at a glance, that powerplant operation is being accomplished in a safe, desirable, undesirable but allowable, or unsafe region. The powerplant instrument color marking scheme consists of three colors: red, green, and yellow. The regulations specify only the minimum markings required for safety; also, additional markings may be approved. The simplest, adequate markings should be the goal. All markings should be explained in the Aircraft Flight Manual.

Generally, there are three types of powerplant instruments: the conventional round dial needle indicating type, the more recently designed vertical or horizontal scale indicators, and the digital read-out type.

When marking the round dial type instrument, normally the color markings should be placed directly over the instrument graduations. If, in this position, the markings interfere with the instrument's readability from the normal crew position, adjustment of the color markings to above or below the graduations should be considered.

Vertical or horizontal scale type instruments may utilize a servo-driven indicator moving along a flat, fixed scale; an indicator bar sweeping through an arc over a curved, convex scale (drum type); or

a servo-driven tape moving against a fixed pointer. The same basic color markings apply; however, their positioning obviously differs.

On a vertical or horizontal scale instrument, a red line or stripe applied transversely from edge-to-edge to mark maximum and minimum (when applicable) safe operating limits will be comparable to the red radial line applied to round dial-type instruments. Green, yellow, or red bracket shaped transverse lines or stripes adjacent to or on the side frames or on both sides of the instrument with the bracket ends of the lines at the specified range limit graduations is a practical method of conveying the same type of information as is provided by the comparable arcs on the dial type instrument. On a moving tape instrument, the operating range markings are either on the face of the tape or affixed adjacent to the tape.

While digital read-out type instruments do not lend themselves to conventional markings, some comparable range markings are required. One suggested marking method is a placard placed near the instrument listing the limits of the applicable ranges. The numbers should be printed in the corresponding color, i.e., maximum limit in red print, normal operating range in green print, etc. Another suggested method is small red, green, and yellow signal lights adjacent to the digital display. The green and yellow lights should be a steady illumination corresponding to the same values as the green and yellow arcs, respectively. The red light, flashing 2 to 4 times per second, corresponds to the red radial limits while a steady red light matches the red arc marking.

4. INSTRUMENT MARKING GUIDELINES. Since most instruments in current use are the round dial, moving needle indicator type, paragraphs 4 and 5 of this circular describe the markings in terms of round dial instruments. The colors should match Federal Standard 595 colors No. 11105 (red), No. 13655 (yellow), and No. 14260 (green).

- a. The color red indicates a dangerous condition and requires a specific action on the part of the aircrew. The specific action to be taken should be described in detail in the Aircraft Flight Manual.

Red radial lines should be used to identify only the established maximum and minimum (if applicable) safe operating limits. Where appropriate, the maximum should be the limit for takeoff operation. A red radial line should not be used to indicate the maximum continuous operating limit, or any limit, other than the minimum, when this limit is less than the maximum safe operating limit. The use of multiple red radials should be avoided to minimize confusion on the part of the aircrew.

The limitations are those required to be established and demonstrated under the type certification standards applicable to the particular aircraft.

- b. The color green is used to indicate a safe condition for operation, both ground and flight. Where applicable (1) the high value end of the green arc should indicate the maximum limit for continuous operation, (2) the low value end of the green arc should indicate the minimum limit for continuous operation. The green arc should cover all modes of safe, continuous operation; where appropriate, there should be blank gaps, or other colors, inserted into this green color band. Either the upper or lower end of the green arc may extend to a red radial or stop short of it.
- c. The color yellow is used to indicate either a takeoff or precautionary range where limited operation is permissible as directed by the applicable Aircraft Flight Manual. An example of compliance with the precautionary range requirement is the yellow arc marking used to indicate the range of temperature on the carburetor air temperature gauge where carburetor icing may occur.

The takeoff range yellow arc may be omitted on instruments where the space between the green arc and the red radial is too small to allow a "clearly visible" marking (reference FAR 23.1543(b), 25.1543(b), 27.1543(b), and 29.1543(b)).

- d. The red arc requirement may be satisfied by marking the applicable instruments for all speed ranges which are restricted because of excessive vibration or other stresses induced by large rotating or reciprocating masses such as the engine, propeller, turbine, fan, rotor, drive shaft, transmission, or any combination of these components.
- e. Red radials should be located so that the edge nearest the normal operating range is placed on the limit value. In use, when the needle point touches the edge of the red radial nearest the green arc, the limit is met.
- f. As the technology of instrument development progresses, instruments are expected which will combine the basic engine parameter read-out function with other factors which influence the operating limits of the basic read-out. In some cases the range markings may be attached to and be driven by a separate mechanism and thus be moved to the applicable limits as determined from the influencing conditions. An example of such an instrument may be an Exhaust Gas Temperature gauge in which the red radial is positioned by an Outside Air Temperature sensor so that the displayed maximum allowable EGT matches existing outside conditions. With a single

gauge of this configuration, the pilot need not read values from separate gauges to determine whether engine operation is within the safe region.

- g. To satisfy the requirement for clearly visible markings, the following minimum dimensions should be observed. These dimensions are adequate for low light level conditions at a nominal 28" viewing distance.

Red Radial - 0.05" wide, 0.30" long

Red, Yellow, or Green Arc - 0.10" wide, length as required

5. SUGGESTED METHODS OF MARKING AIRCRAFT POWERPLANT INSTRUMENTS. A hypothetical instrument dial with illustrative range markings is shown in Figure 1. This dial face is intended only as a guide; some instruments will need only a few of these markings.

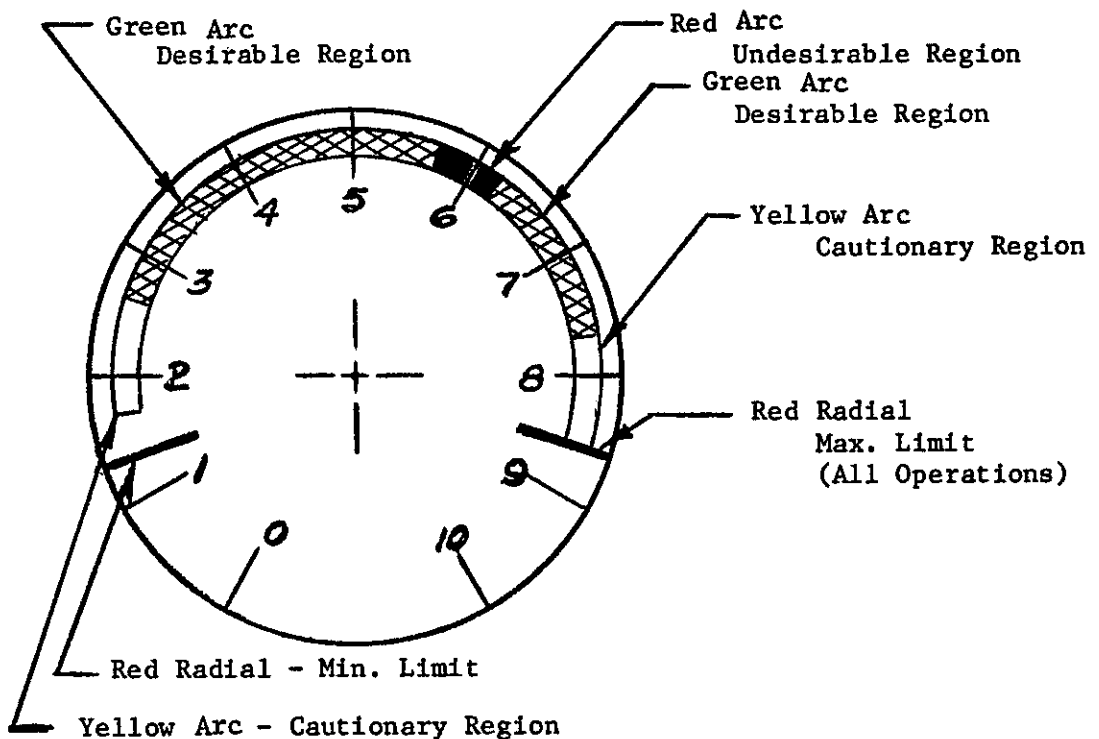


Figure 1. Instrument Dial Illustrating Range Markings for Continuous Operation. No Scale.

The markings on a typical Vertical Tape Instrument are illustrated in Figure 2.

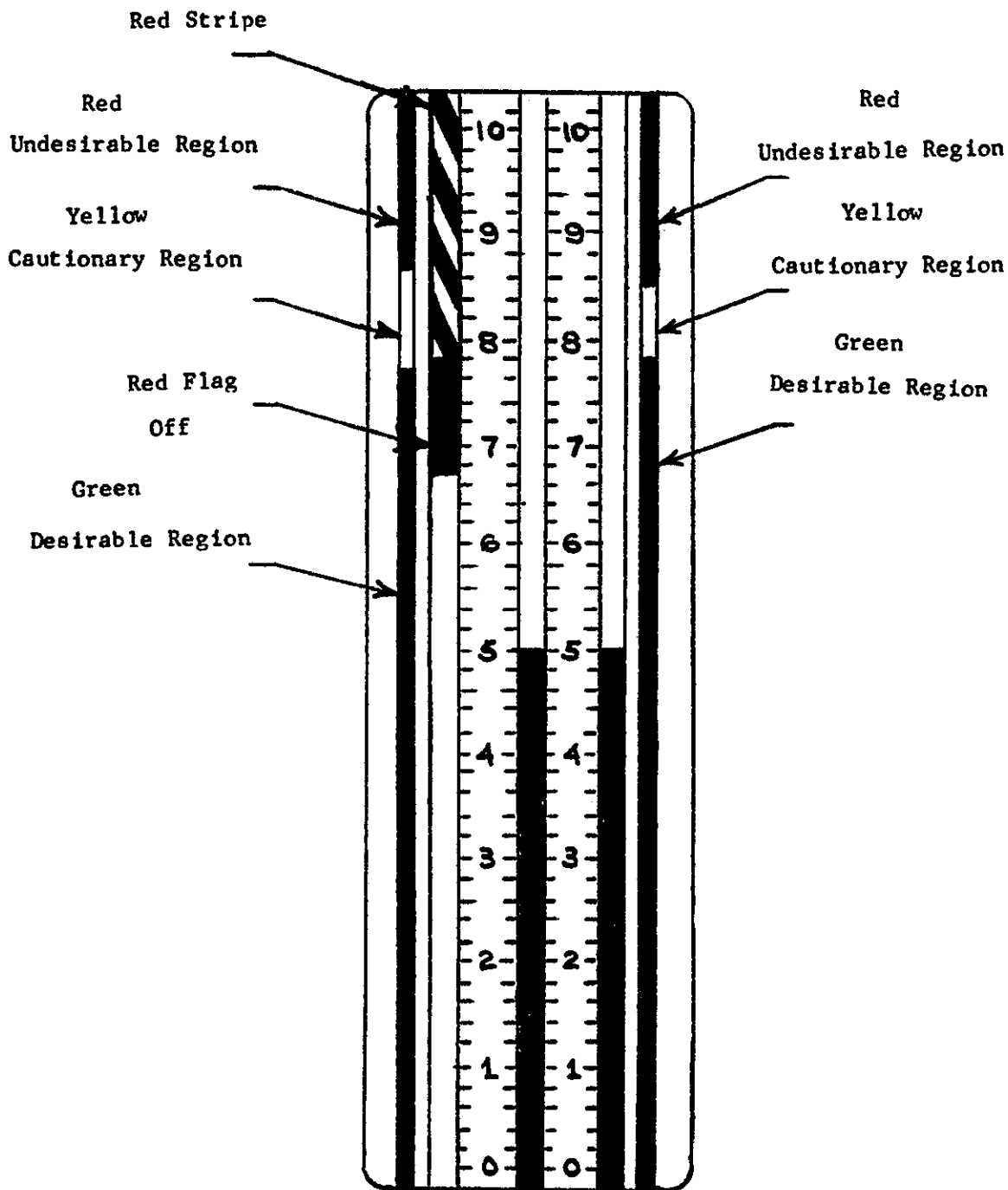


Figure 2

a. Carburetor Air Temperature (Reciprocating Engine Aircraft)

Red Radial - At maximum permissible carburetor inlet air temperature recommended by the engine manufacturer.

Green Arc - Normal operating range for trouble-free operation with the upper limit at maximum permissible carburetor inlet air temperature and the lower limit at the point where icing may be anticipated. Additional green arc may be required in the temperature range below the icing range.

Yellow Arc - Range indicating where icing is most likely to be encountered.

b. Cylinder Head Temperature (Reciprocating Engine Aircraft)

Red Radial - At maximum permissible cylinder head temperature.

Green Arc - From maximum permissible temperature for continuous operation to minimum recommended by the engine manufacturer for continuous operation.

Yellow Arc - From maximum temperature for continuous operation to maximum permissible temperature.

c. Manifold Pressure (Reciprocating Engine Aircraft)

Red Radial - At maximum permissible manifold absolute pressure for dry or wet operation, whichever is greater.

Green Arc - From maximum permissible pressure for continuous operation to the minimum pressure selected by the aircraft manufacturer for cruise power.

Yellow Arc - From maximum pressure for continuous operation to maximum permissible pressure.

d. Fuel Pressure (Reciprocating and Turbine Engine Aircraft)

Red Radial - At maximum and/or minimum permissible pressures established as engine operating limitations.

Green Arc - Normal operating range.

Yellow Arc - Cautionary ranges indicating any potential hazard in the fuel system such as malfunction, icing, etc.

e. Oil Pressure (Reciprocating and Turbine Engine Aircraft)

Red Radial - At maximum and/or minimum permissible pressures established as engine operating limitations.

Green Arc - Normal operating range.

Yellow Arc - Cautionary ranges indicating any potential hazard due to overpressure during cold start, low pressure during idle, etc.

f. Oil Temperatures (Reciprocating and Turbine Engine Aircraft)

Red Radial - At maximum and/or minimum permissible temperatures established as engine operating limitations.

Green Arc - Normal operating range.

Yellow Arc - Cautionary ranges indicating any potential hazard due to overheating, high viscosity at low temperature, etc.

g. Tachometer (Reciprocating Engine Aircraft)

Red Radial - At maximum permissible rotational speed (r.p.m.).

Green Arc - From maximum rotational speed for continuous operation to minimum recommended for continuous operation (except in the restricted ranges, if any).

Yellow Arc - From maximum rotational speed for continuous operation to maximum permissible rotational speed.

Red Arc - Range(s) in which operation is restricted, except to pass through, for all operating conditions because of excessive stresses, etc.

h. Torque Indicator (Reciprocating, Turboprop and Turboshaft Engine Aircraft).

Red Radial - At maximum permissible torque pressure for dry or wet operation, whichever is greater.

Green Arc - From maximum torque pressure for continuous operation to minimum torque pressure recommended.

Yellow Arc - From maximum torque pressure for continuous operation to maximum permissible torque pressure.

i. Exhaust Gas Temperature (Turbine Engine Aircraft)

Red Radial - At maximum permissible gas temperature for wet or dry operation, whichever is greater.

Green Arc - From maximum permissible temperature for continuous operation to minimum recommended by the engine manufacturer.

Yellow Arc - From maximum temperature for continuous operation to maximum permissible gas temperature.

j. Outside Air Temperature/Exhaust Gas Temperature Gauge (If Applicable)

Some turboshaft/turboprop engines are certificated having an EGT limit which varies with ambient temperature conditions. Consequently, this has necessitated devising a method for the pilot to readily determine the takeoff and maximum continuous EGT limit for each ambient condition in order that a constant turbine inlet temperature is maintained. On those aircraft that are temperature limited, it is possible to provide for determination of the necessary compensation by installation of an OAT vs. EGT gauge. The OAT/EGT gauge normally has two EGT scales adjacent to the ambient temperature scale. The scales indicate the takeoff power and maximum continuous power exhaust gas temperature limits. The pilot, by referring to the gauge, will observe the outside air temperature needle and then read the matching allowable EGT (which is shown directly beneath the gauge pointer) for the power condition at which operations are being performed. For a particular engine at outside air temperatures above 40°C, the EGT limit may be constant at 638°C for takeoff power and at 621°C for maximum continuous power. These constant values of temperature are portrayed by a red arc, on the face of the gauge, at the ends of the EGT limits scales.

k. Tachometer (Turbine Engine Airplanes)

Red Radial - At maximum permissible rotational speed (r.p.m.).

Green Arc - From maximum rotational speed for continuous operation to minimum rotational speed recommended for continuous operation.

Yellow Arc - From maximum rotational speed for continuous operation to maximum rotational speed.

1. Dual Tachometer (Helicopter)

Red Radial:

Dual Tachometer (Engine) - At maximum permissible rotational speed (r.p.m.).

Dual Tachometer (Rotor) - At maximum and minimum rotor speed (r.p.m.) for power "off" operational condition.

Green Arc:

Dual Tachometer (Engine) - From maximum rotational speed for continuous operation to minimum recommended for continuous operating power (except in the restricted ranges, if any).

Dual Tachometer (Rotor) - From maximum to minimum normal operating range.

Yellow Arc:

Dual Tachometer (Engine) - Precautionary ranges, such as altitude limits.

m. Gas Producer (N1) Tachometer (Turboshaft Helicopter)

Red Radial - At maximum permissible rotational speed (r.p.m.).

n. Thrust Indicator (Turbine Engine Airplanes)

No markings because values vary considerably with temperature and altitude operating conditions. Limiting gauge markings cannot be established for all such conditions. It is necessary to refer to thrust setting charts (EPR or PT7) for the proper values.



C. R. MELUGIN, JR.
Acting Director, Flight Standards Service

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FEDERAL AVIATION ADMINISTRATION
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