

Appendix C
Electronic Display Symbology for Engine Displays

RATIONALE

This document has been reaffirmed to comply with the SAE 5-Year Review policy.

FOREWORD

Changes in this reaffirm are format/editorial only.

This document is an Appendix to ARP4102-7 - Electronic Displays issued July 1988.

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SAE ARP4102-7

APPENDIX C ELECTRONIC DISPLAY SYMBOLOGY FOR ENGINE DISPLAYS

C.1 SCOPE:

This appendix recommends display symbology for Electronic Engine Displays (ED) used on the flight deck of turbofan power transport aircraft.

C.2 GENERAL:

C.2.1 EDs should incorporate only that symbology appropriate for the installed engine.

C.2.2 EDs should at all times be appropriate to the phase of flight, the type of operation (normal versus non-normal) and the automatic monitoring capability of the aircraft relative to engine parameters. The goal should be to limit displays at a given time to those required by the pilot to control the aircraft, to observe operating limits and to analyze the current status of the engines. For example, for aircraft with extensive automatic monitoring and alerting capability, it may be desirable to provide the pilot with continuous display of the thrust parameter only; all other engine parameters would be available on an exception basis; i.e., automatically called up for a particular phase of flight or a malfunction/exceedance or manually called up by the pilot.

C.2.3 Displays may vary in size and shape. The total symbology content of a display should not result in clutter. Thus, small display formats should not be designed to contain all the symbology that can be satisfactorily included in larger displays.

C.2.4 Symbols should be grouped so that pertinent information is presented clearly and unambiguously; for example, actual, reference and redline value symbols should be presented so that they interact properly.

C.2.5 Each engine should be readily identifiable and its parameters easily compared with those of other engines.

C.2.6 Displays shall be evaluated in a dynamic environment to ensure they perform their intended function throughout the entire operating envelope, that there is proper integration between individual symbols and displays and that displays do not contain human factor deficiencies.

C.2.7 Recommendations for display element features should be observed whenever possible; however, symbols may be refined or tailored to specific installations as a result of dynamic testing.:

C.3 ENGINE DISPLAY SYMBOLOGY:

C.3.1 The matrix on the following page shows, for each engine parameter, the "elements" that should be included in that parameter's display. Note that the last two columns are "continuous" and "conditional". Except for the primary thrust parameter, which should be "continuous", the recommendation for continuous or conditional depends on the automatic monitoring and pilot alerting capability of the aircraft systems.

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C.3.2 The charts following the Display Requirements matrix show examples of typical existing configurations of each display element along with verbal recommendations for the "ideal" configuration.

Pages 51 to 67 show examples of typical existing symbology for each display element with remarks and recommendations pertaining to the "ideal" symbology.

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FLIGHT DECK AND HANDLING QUALITIES STANDARDS FOR TRANSPORT AIRCRAFT

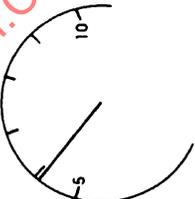
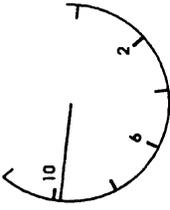
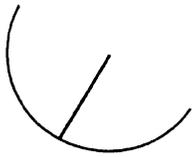
ENGINE DISPLAY REQUIREMENTS

DISPLAY ELEMENT												
ENGINE PARAMETER	ANALOG	DIGITAL	SCALE BRADUATIONS INCREMENTS	AMBER RANGE	REDLINE	EXCEEDANCE DISPLAY	THRUST MODE INDICATION	THRUST REF LIMIT	MAX THRUST REFERENCE	CMD DISPLAY	CONTINUOUS DISPLAY	CONDITIONAL DISPLAY
EPR (1)(3)	+	*	*	-	-	-	+	+	*	*	+	-
N1 (2)(3)	+	*	*	+	*	*	+	+	*	*	+	-
N _n	-	*	-	+	*	*	-	-	-	-	o	o
EGT	*	*	-	+	*	*	-	-	-	-	o	o
FF	-	*	-	-	-	-	-	-	-	-	o	o
OIL P	-	*	-	+	-	-	-	-	-	-	o	o
OIL T	-	*	-	+	-	-	-	-	-	-	o	o
OIL Q	-	*	-	*	-	-	-	-	-	-	o	o
FUEL P	-	*	-	-	-	-	-	-	-	-	o	o
FUEL T	-	*	-	-	-	-	-	-	-	-	o	o
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VIB	-	*	-	-	-	-	-	-	-	-	o	o

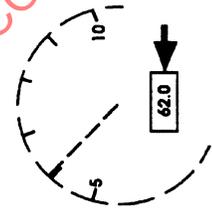
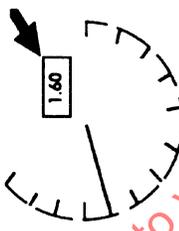
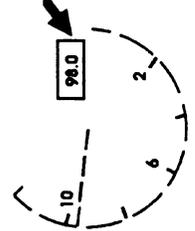
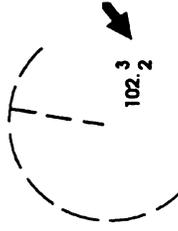
NOTES: 1) IT IS ASSUMED THAT IF EPR DISPLAY IS PROVIDED, EPR IS THE PRIMARY THRUST PARAMETER.
 2) REQUIREMENTS SHOWN FOR N1 APPLY ONLY WHEN N1 IS BEING USED AS THE PRIMARY THRUST PARAMETER BY DESIGN OR BY DEFAULT (AS IN CASE OF FAILURE OF EPR SYSTEM). OTHERWISE "n_n" REQUIREMENTS APPLY.
 3) A NORMALIZED THRUST PARAMETER, INDICATING PERCENT OF MAXIMUM AVAILABLE THRUST AT CURRENT AMBIENT CONDITIONS, MAY BE USED.

LEGEND:
 + = SHALL BE PROVIDED
 * = SHOULD BE PROVIDED
 - = NEED NOT BE PROVIDED
 o = SHOULD BE CONTINUOUS OR CONDITIONAL DEPENDING ON THE AUTOMATIC MONITORING AND ALERTING CAPABILITY OF THE AIRCRAFT

ENGINE DISPLAY ELEMENTS

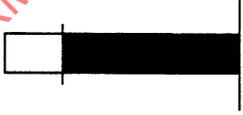
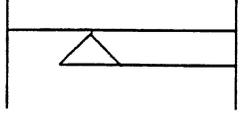
NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
1. SCALE/POINTER (RADIAL)	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>N_1</p> </div> <div style="text-align: center;">  <p>N_1</p> </div> <div style="text-align: center;">  <p>N_1</p> </div> </div>	<ul style="list-style-type: none"> • SUBTENDED ANGLE OF THE POINTER SHOULD BE A MINIMUM OF 180 DEGREES. • RANGE OF THE ARC SHOULD COINCIDE WITH THE POINTER RANGE. • ORIENTATION OF THE POINTER AT MAXIMUM VALUE SHOULD BE THE 12 O'CLOCK POSITION \pm 60 DEGREES AND SHOULD BE CONSISTENT AMONG PARAMETERS. • MINIMUM AND MAXIMUM VALUES SHOULD BE CLEARLY SEPARATED. • POINTER TIP SHOULD EXTEND TO THE ARC. • UNITS SHOULD BE DISPLAYED IF POTENTIAL FOR CONFUSION EXISTS. • INCREASING VALUES OF THE POINTER SHALL BE IN THE CLOCKWISE DIRECTION. • INDICATOR SHALL DISPLAY PARAMETER VALUES FOR ONLY ONE ENGINE. • SCALE GRADUATION MARKS SHOULD BE USED AND SHOULD: <ul style="list-style-type: none"> - COVER ENTIRE OPERATING RANGE. - BE LINEAR OVER SIGNIFICANT OPERATING RANGE. - BE LOCATED INSIDE THE ARC. - BE LABELED TO PROVIDE RAPID ASSESSMENT OF PARAMETER VALUE. • INDICATOR SHALL DISPLAY ONLY ONE PARAMETER. • TARGET THRUST FOR APPROACH MAY BE DISPLAYED IN MANUAL THRUST MODE.

ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES		REMARKS/RECOMMENDATIONS
2. DIGITAL READ-OUT (RADIAL)	 <p>N₁</p>	 <p>EPR</p>	<ul style="list-style-type: none"> • READ-OUT SHOULD BE SUBSTANTIALLY WITHIN THE CIRCLE OF WHICH THE ARC IS A PART. • DIGITS SHOULD MAKE DISCRETE CHANGES. THE LEAST SIGNIFICANT DIGIT MAY BE ROLLING. OSCILLATION OF DIGITS SHOULD BE MINIMIZED. • LEADING ZEROES SHOULD BE SUPPRESSED. • NEGATIVE VALUES SHOULD BE ANNOTATED. • READ-OUT OF PARAMETER VALUE MAY BE OUTLINED BY A BOX OR NEUTRAL BACKGROUND; BOX, DIGITS AND POINTER SHOULD BE THE SAME COLOR AS THE CORRESPONDING SEGMENT OF THE SCALE. BOX SIZE SHOULD REMAIN CONSTANT. • DISCRIMINATION SHOULD BE CONSISTENT WITH THE SETTING ACCURACY REQUIREMENT OF THE PARAMETER WITH RESPECT TO PERFORMANCE AND OPERATING LIMIT CONSIDERATIONS.
	 <p>N₁</p>		
	 <p>N₁</p>		

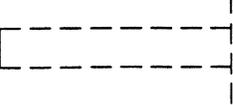
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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES		REMARKS/RECOMMENDATIONS
3. SCALE/POINTER (LINEAR)			<ul style="list-style-type: none"> • ACTUAL PARAMETER VALUE MAY BE DEPICTED BY "SOLID TAPE" OR POINTER. • THE RANGE OF THE INDICATOR SHOULD COINCIDE WITH THE RANGE OF VALUES FOR THE PARAMETER. • SIZE OF THE INDICATOR SHOULD BE SUFFICIENT TO READILY DETERMINE COARSE POWER SETTINGS AND BALANCE BETWEEN ENGINES. • INCREASING ACTUAL VALUES SHALL BE IN THE UPWARD DIRECTION. • UNITS SHOULD BE DISPLAYED IF THE POTENTIAL FOR CONFUSION EXISTS. • INDICATORS SHALL BE CLEARLY IDENTIFIED AND READILY DISTINGUISHABLE FROM BACKGROUND. • INDICATORS SHALL BE GROUPED BY PARAMETERS; E.G. ALL N1 SHOULD BE GROUPED TOGETHER. • EACH PARAMETER GROUP SHALL BE CLEARLY IDENTIFIED. • SCALE GRADUATION MARKS SHOULD BE USED AND SHOULD: <ul style="list-style-type: none"> • COVER ENTIRE OPERATING RANGE. • BE LINEAR OVER SIGNIFICANT OPERATING RANGE. • BE EXTERNAL TO THE VERTICAL "TAPE" REPRESENTATION. • BE LABELED TO PROVIDE RAPID ASSESSMENT OF PARAMETER VALUE.
			
			

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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES		REMARKS/RECOMMENDATIONS
4. DIGITAL READ-OUT (LINEAR)	<p>N₁</p> <div style="border: 1px solid black; padding: 2px; display: inline-block; margin: 5px;">101.2</div> 		<ul style="list-style-type: none"> • DIGITAL READ-OUT SHOULD BE READILY ASSOCIATED WITH THE CORRESPONDING ANALOG INDICATOR. THE POSITION OF THE DIGITAL READ-OUT MAY MOVE WITH THE CORRESPONDING ANALOG INDICATOR. • DIGITS SHOULD MAKE DISCRETE CHANGES. THE LEAST SIGNIFICANT DIGIT MAY BE ROLLING. INSIGNIFICANT OSCILLATIONS OF DIGITS SHOULD BE MINIMIZED. • LEADING ZEROES SHOULD BE SUPPRESSED. • NEGATIVE VALUES SHOULD BE ANNOTATED. • READ-OUT OF PARAMETER VALUE MAY BE OUTLINED BY A BOX OR NEUTRAL BACKGROUND; BOX, DIGITS AND POINTER SHOULD BE THE SAME COLOR AS THE CORRESPONDING SEGMENT OF THE SCALE. BOX SIZE SHOULD REMAIN CONSTANT. • DISCRIMINATION SHOULD BE CONSISTENT WITH THE SETTING ACCURACY REQUIREMENT OF THE PARAMETER WITH RESPECT TO PERFORMANCE AND OPERATING LIMIT CONSIDERATION.

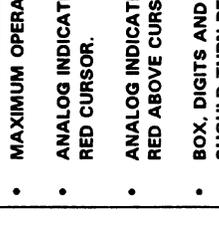
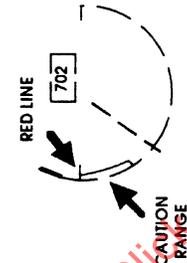
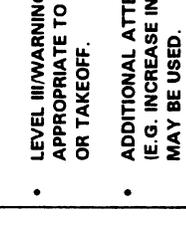
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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
<p>5. LEVEL II/ CAUTION RANGE</p>	<p>The first diagram shows a semi-circular scale for EGT. A red line is at 702. A dashed arc indicates a caution range from 5 to 10. The second diagram shows a similar scale with a 'TAKEOFF RED LINE' and a 'CAUTION RANGE' indicated by a dashed arc. The third diagram shows a scale with an 'AMBER "/> </p>	<ul style="list-style-type: none"> OPERATION IN THIS RANGE MAY BE TIME LIMITED OR REQUIRE MONITORING OF OTHER PARAMETERS. RANGE AND END POINTS SHOULD BE SHAPE AND COLOR CODED. BOX, DIGITS AND POINTER (AS APPLICABLE) SHOULD TURN AMBER WHEN OPERATING IN THIS RANGE. THIS FEATURE MAY BE INHIBITED FOR APPROVED OPERATION IN THE CAUTION RANGE; E.G. WHEN OPERATING ABOVE MAXIMUM CONTINUOUS EGT DURING TAKEOFF PHASE. BOX, DIGITS AND POINTER (AS APPLICABLE) SHOULD TURN RED AFTER TIME LIMIT IN AMBER RANGE (IF APPLICABLE) IS EXCEEDED. DISPLAYED RANGE SHOULD BE APPROPRIATE TO PHASE OF FLIGHT; E.G. STARTING OR TAKEOFF; AND TO ENGINE OPERATING REGIME; E.G. WHERE OIL PRESSURE "CAUTION" RANGE IS A FUNCTION OF ENGINE SPEED.

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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES		REMARKS/RECOMMENDATIONS
6. LEVEL III/ WARNING	 <p>EGT</p>	 <p>IGT</p>	<ul style="list-style-type: none"> • MAXIMUM OPERATING VALUE. • ANALOG INDICATION SHALL BE MARKED BY RED CURSOR. • ANALOG INDICATION SCALE MAY BE MARKED RED ABOVE CURSOR. • BOX, DIGITS AND POINTER (IF APPLICABLE) SHOULD TURN RED WHEN REDLINE IS REACHED OR WHEN TIME LIMIT IN LEVEL II/CAUTION RANGE IS EXCEEDED. • LEVEL III/WARNING DISPLAY SHOULD BE APPROPRIATE TO PHASE OF FLIGHT; E.G. START OR TAKEOFF. • ADDITIONAL ATTENTION GETTING FEATURES (E.G. INCREASE IN THICKNESS OF RED BAND) MAY BE USED.
	 <p>EGT</p>		
	 <p>EGT</p>		<p>BOX SURROUNDING DIGITS APPEARS (RED) WHEN OVER RED LINE</p>

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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
7. EXCEEDANCE DISPLAY	<p>The figure shows three examples of engine exceedance displays. Each example consists of a semi-circular gauge with a dashed red line representing the maximum value. A red needle indicates the current value, and a digital display shows the exact value.</p> <ul style="list-style-type: none"> EGT: The needle is at the top of the scale, and the digital display shows 600. N₂: The needle is at the top of the scale, and the digital display shows 93.0. N₁: The needle is at the top of the scale, and the digital display shows 117.8. A second digital display shows 102.3. 	<ul style="list-style-type: none"> CURSOR OR ADDITIONAL DIGIT DISPLAY SHALL APPEAR TO INDICATE MAXIMUM VALUE REACHED DURING REDLINE EXCEEDANCE. MAY ALSO DISPLAY TIME ABOVE REDLINE. SHOULD BE RESETTABLE AND RETRIEVABLE BY THE PILOT.

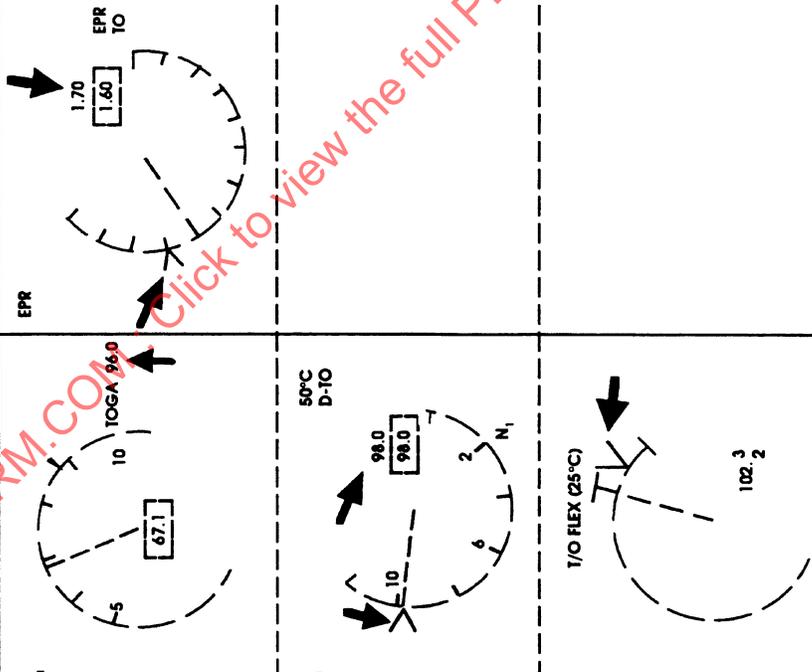
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ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
<p>B. THRUST MODE ANNUNCIATION</p>		<ul style="list-style-type: none"> INDICATES SELECTED THRUST MODE; E.G. TAKEOFF, REDUCED TAKEOFF, MAXIMUM CONTINUOUS, ETC. SINGLE DISPLAY COMMON TO ALL ENGINES SHOULD BE USED.

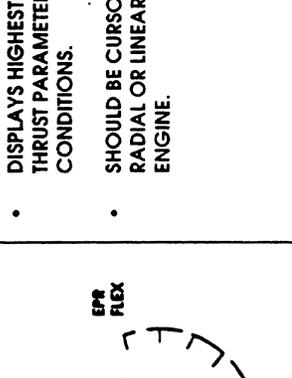
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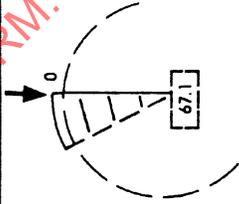
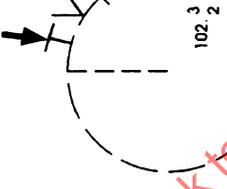
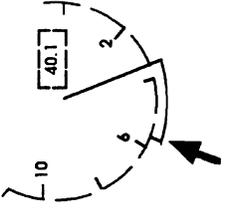
NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
<p>9. THRUST REFERENCE LIMIT</p>		<ul style="list-style-type: none"> • DISPLAYS UPPER LIMIT (NOT REDLINE) FOR PARTICULAR THRUST MODE SELECTED; E.G. TAKEOFF, REDUCED TAKEOFF, MAXIMUM CONTINUOUS, ETC. • DISPLAY SHOULD INCLUDE A CURSOR ON OUTSIDE EDGE OF RADIAL OR LINEAR SCALE FOR EACH ENGINE AS WELL AS A DIGITAL READ-OUT. • SINGLE DIGITAL DISPLAY COMMON TO ALL ENGINES SHOULD BE USED. • DIGITAL DISPLAY SHOULD BE IN CLOSE PROXIMITY TO THRUST MODE ANNUNCIATION. • FOR ASSUMED TEMPERATURE REDUCED TAKE-OFF, THE APPROPRIATE ASSUMED TEMPERATURE SHOULD BE DISPLAYED. • APPROPRIATE TARGET THRUST VALUE MAY BE DISPLAYED FOR ALL PHASES OF FLIGHT.

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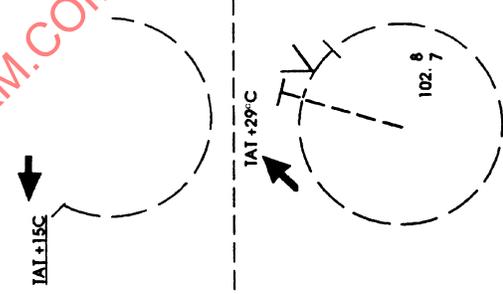
ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
<p>10. MAXIMUM TAKEOFF THRUST REFERENCE</p>	 <p>NOTES:</p> <ul style="list-style-type: none"> - CURSOR CORRESPONDS TO FULL FORWARD THROTTLE POSITION - IF TOGA SELECTED DIGITAL IS AT SAME VALUE AS CURSOR 	<ul style="list-style-type: none"> • DISPLAYS HIGHEST ALLOWABLE VALUE OF THRUST PARAMETER FOR CURRENT AMBIENT CONDITIONS. • SHOULD BE CURSOR ON OUTSIDE EDGE OF RADIAL OR LINEAR SCALE FOR EACH ENGINE.

ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
<p>11. COMMAND DISPLAY</p>  <p>NOTE: "DONUT" CORRESPONDS TO THROTTLE LEVER POSITION. IN MANUAL THRUST MODE, "DONUT" WOULD BE ON TOP END OF ARC AND SIGNIFY COMMAND VALUE.</p>		<ul style="list-style-type: none"> INDICATES VALUE OF THRUST PARAMETER DEMANDED BY INPUT CONTROLLER; E.G. THRUST LEVER OR AUTO THRUST SYSTEM. SHOULD BE CURSOR ON ANALOG SCALE FOR EACH ENGINE.
 <p>DISPLAYS ABOVE SHOW DYNAMIC SITUATION WHERE ACTUAL THRUST IS APPROACHING COMMANDED VALUE.</p>		

ENGINE DISPLAY ELEMENTS

NAME	SYMBOLGY EXAMPLES	REMARKS/RECOMMENDATIONS
12. TOTAL AIR TEMPERATURE (WHEN INCLUDED IN ENGINE DISPLAY)		<ul style="list-style-type: none"> CONTINUOUS DISPLAY "TAT ± ____ C." SINGLE DISPLAY COMMON FOR ALL ENGINES. SHOULD BE IN CLOSE PROXIMITY TO SAT.

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