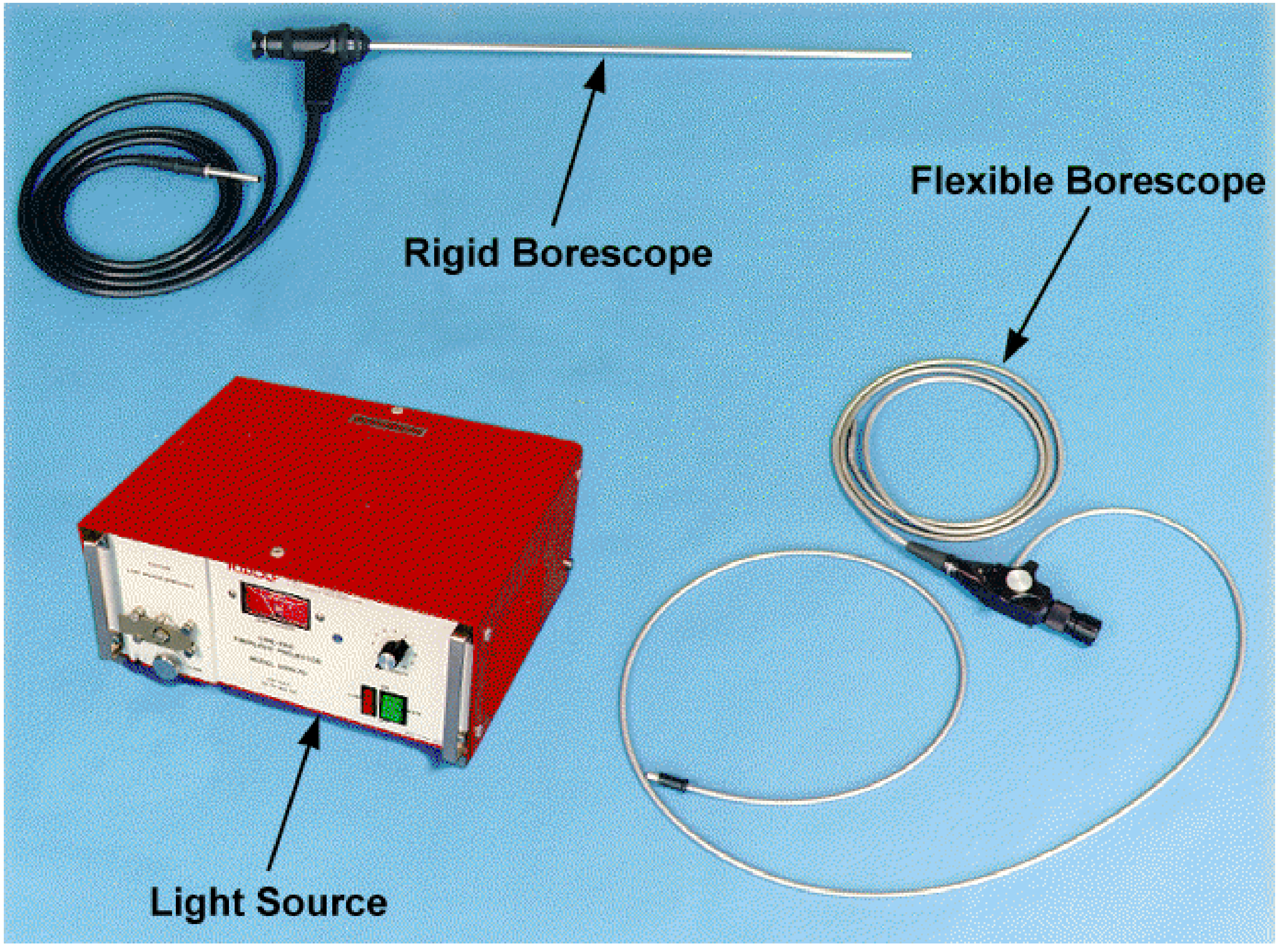
Borescope Inspection

This work was created in order to have an extra knowledge about borescope ,its equipment ,its parts, where it is used ,types and causes of damage that it can be found in each section.

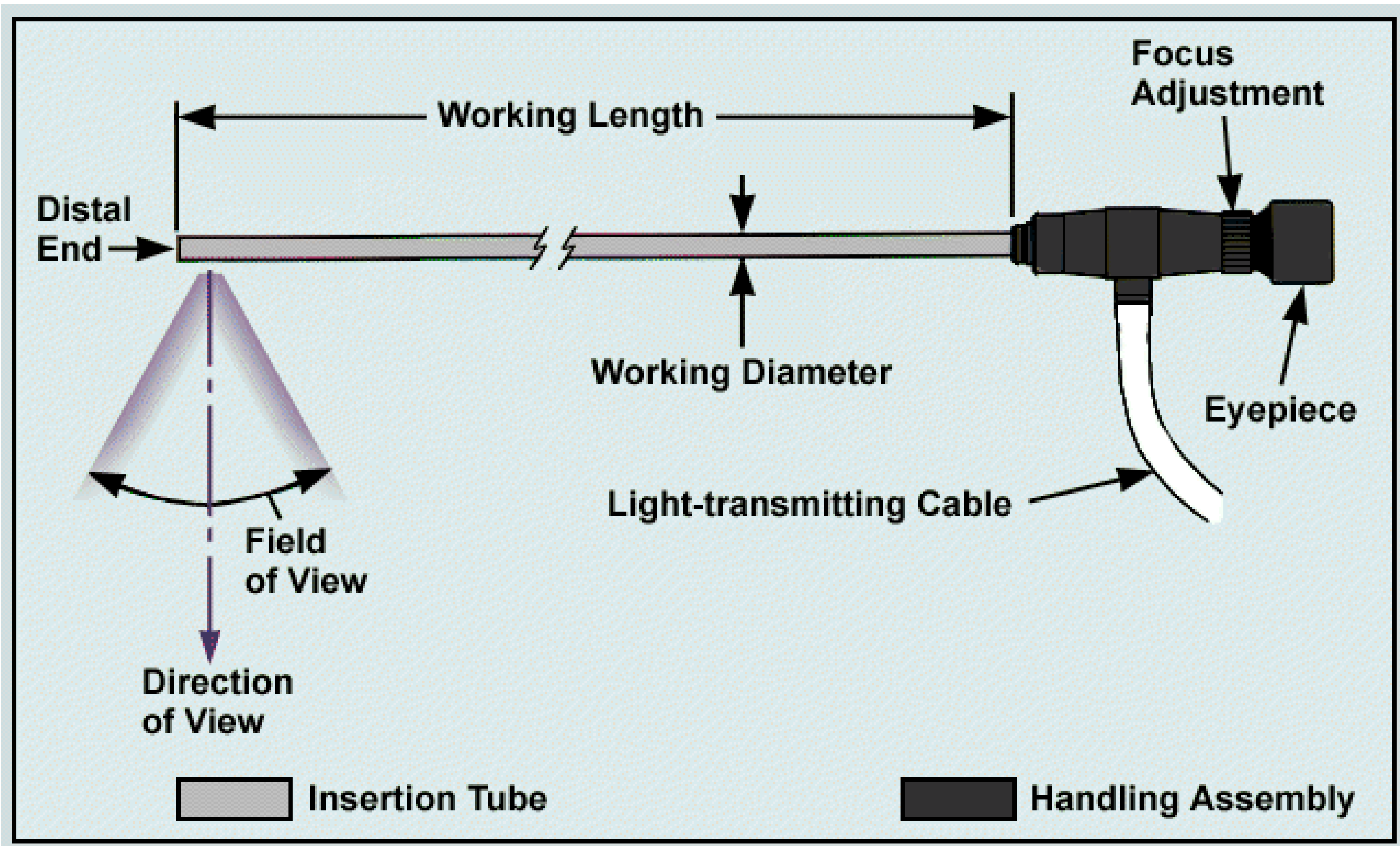
For CF6-50 Engines
Based on the Non Destructive Test manual (GEK 9294)

INDEX

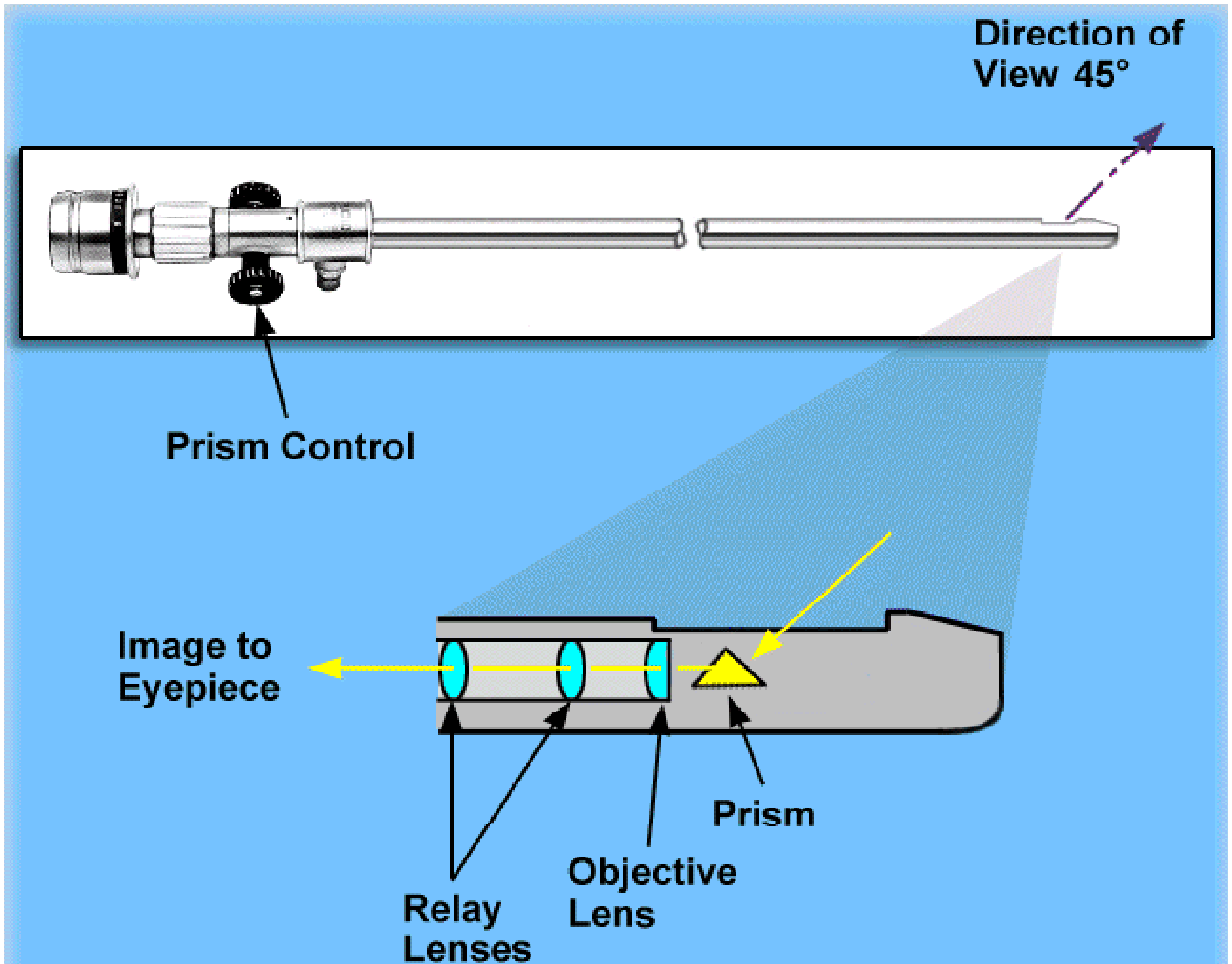
BORESCOPE EQUIPMENT



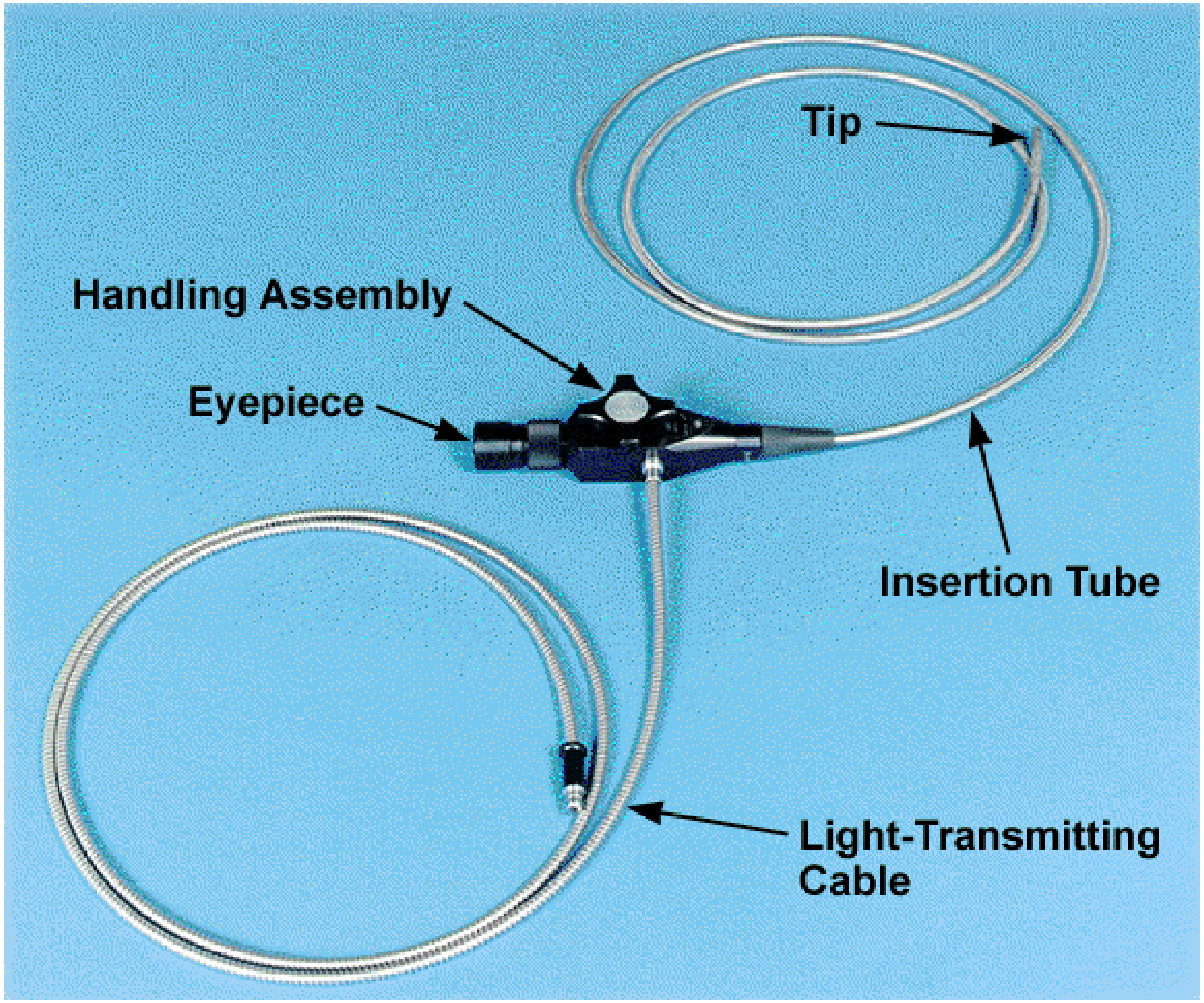
BORESCOPE PARTS - RIGID



BORESCOPE PARTS - RIGID



BORESCOPE PARTS - FLEXIBLE



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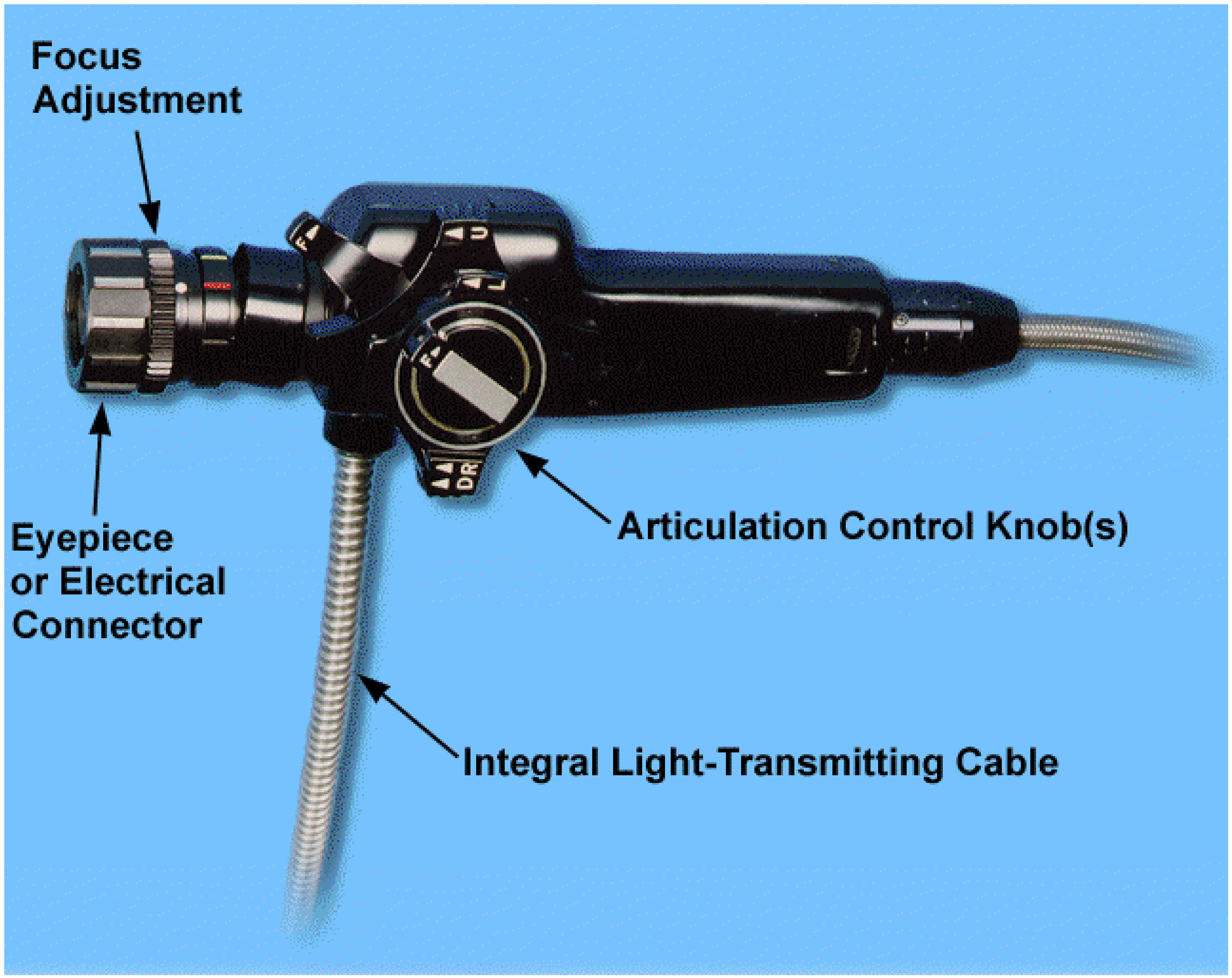
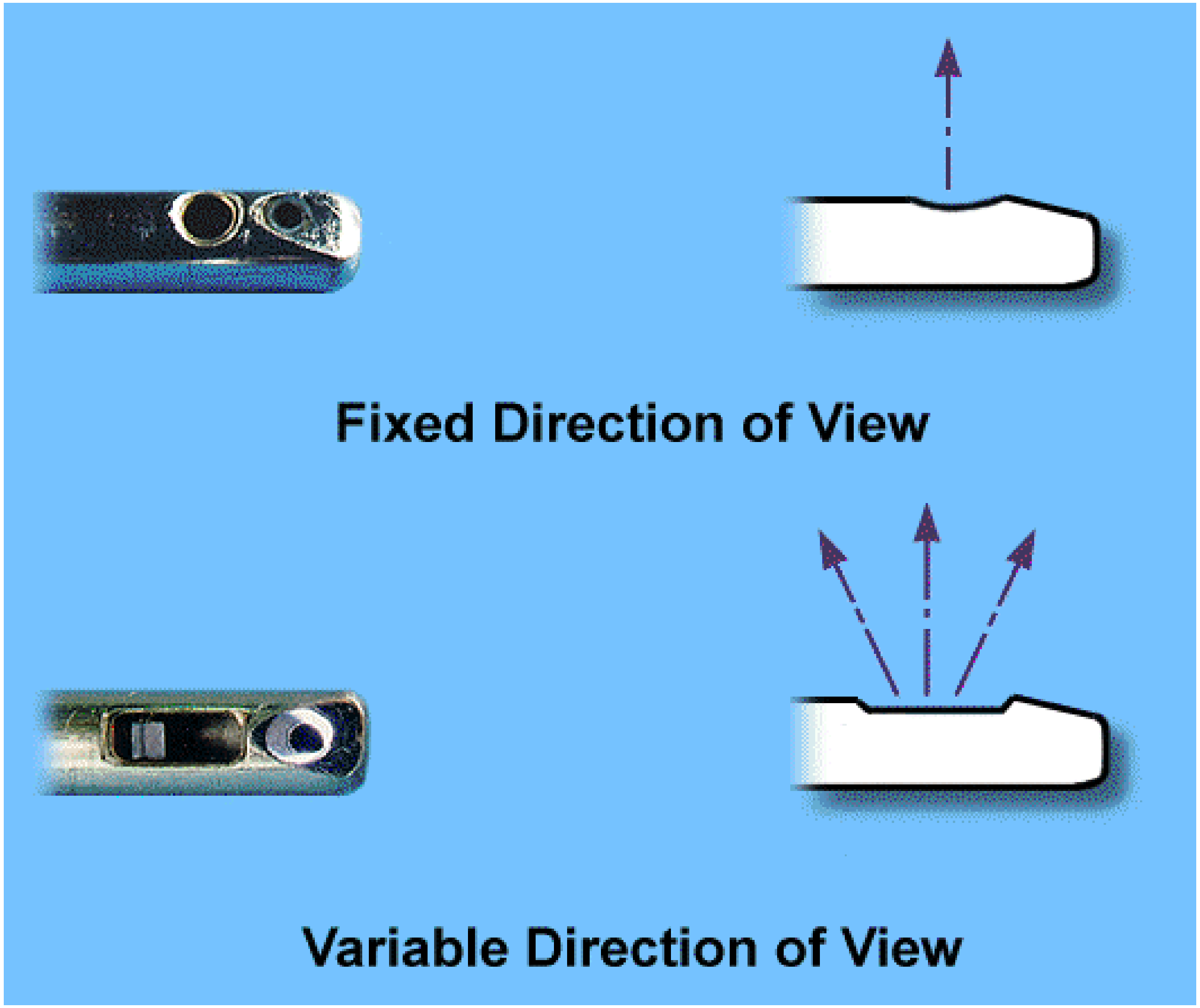
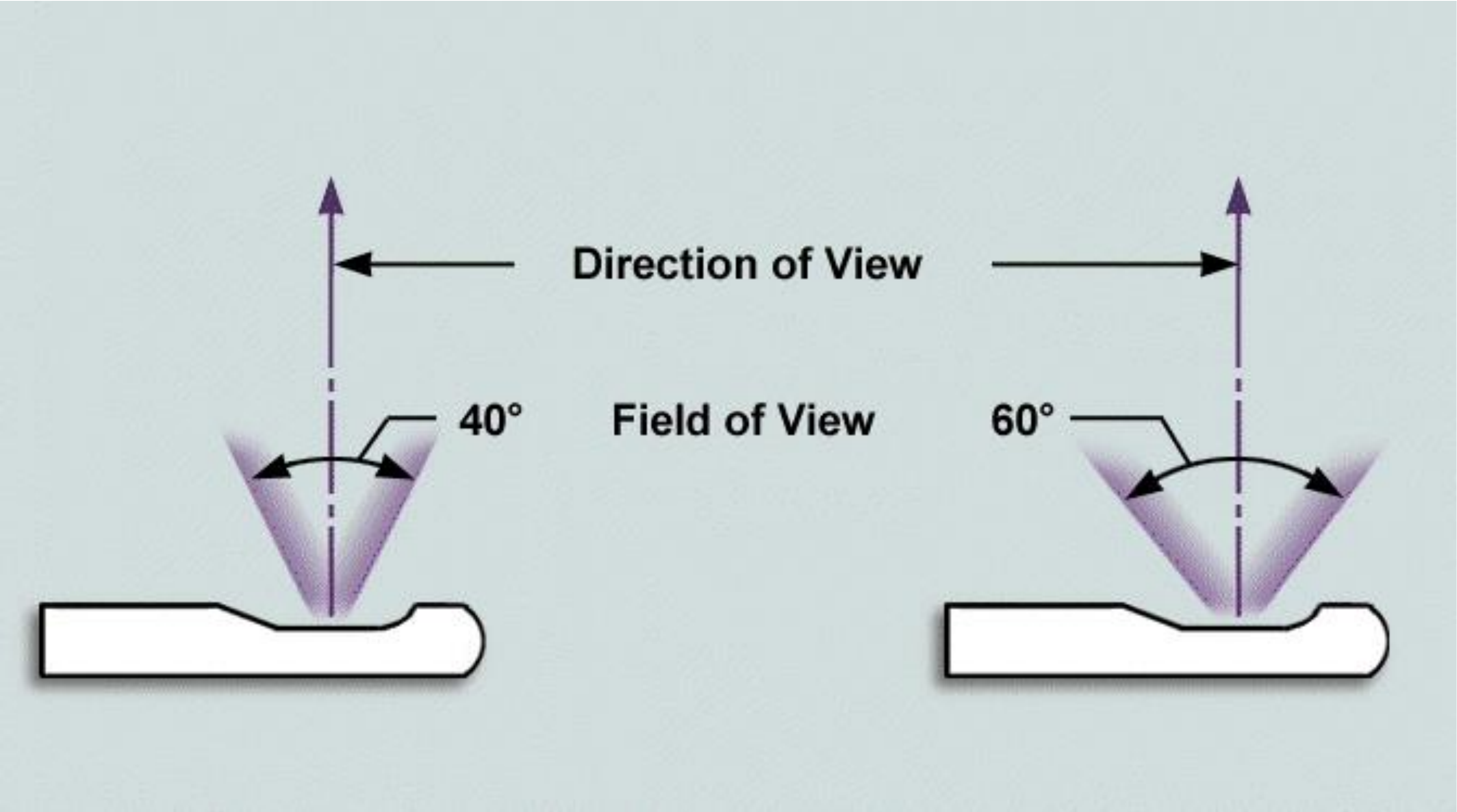


DIRECTION OF VIEW



FIELD OF VIEW



BORESCOPE TEMPERATURE LIMITATIONS

It is not recommended that borescope inspections be accomplished in temperature above 150 ºF (65.6 ºC).

To increase the engine cool –down rate after shutdown, engine “motoring” utilizing the engine starter at 5 minute “ON” – 5 minutes “OFF” cycles for one hour is recommended. This will reduce the hot section area temperature sufficiently to allow fiber optic method of inspection at that time

If engine starter motoring is used, it is further recommended that engine hot section inspections be accomplished within 20 minutes after the motoring cycles are completed.

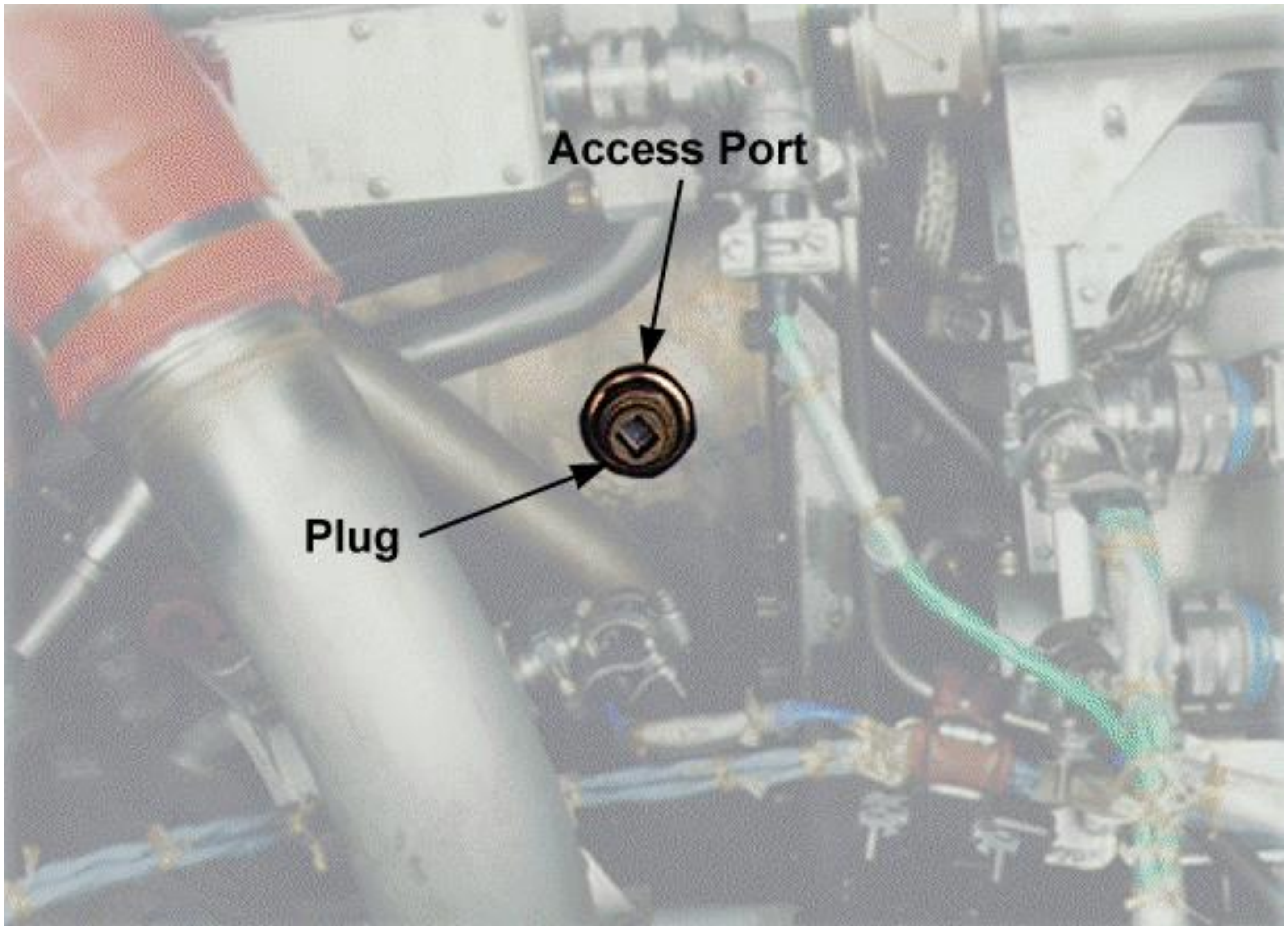
BORESCOPE TEMPERATURE LIMITATIONS

Borescope Port Identification Per NDT Manual	Component Inspected	Gas. Temp At Ground Idle - F°	Metal Temp. At Ground Idle - F°	Without Motoring Time To Reach 100°F (37.8°C)
B1-0	Comp.-Stg.1	78(25.6°C)	80(26.7°C)	10 Min.
B1-1	Comp.-Stg.2	93(33.9°C)	95(35.0°C)	10 Min.
B1-2	Comp.-Stg.3	101(38.3°C)	103(39.4°C)	10 Min.
B1-3	Comp.-Stg.4	112(44.4°C)	114(46.1°C)	10 Min.
B1-4	Comp.-Stg.5	126(52.2°C)	129(53.9°C)	10 Min.
B1-5	Comp.-Stg.6	134(56.7°C)	136(57.8°C)	10 Min.
B1-6	Comp.-Stg.7	120(48.9°C)	122(50.0°C)	10 Min.
B1-7	Comp.-Stg.8	146(63.3°C)	149(65.0°C)	30 Min.
B1-8	Comp.-Stg.9	172(77.8°C)	175(79.4°C)	30 Min.
B1-9	Comp.-Stg.10	193(89.4°C)	197(91.7°C)	30 Min.
B1-10	Comp.-Stg.11	213(100.6°C)	217(102.8°C)	30 Min.
B1-11	Comp.-Stg.12	240(115.6°C)	245(118.3°C)	60 Min.
B1-12	Comp.-Stg.13	260(126.7°C)	265(129.4°C)	60 Min.
B1-13	Comp.-Stg.14	284(140.0°C)	290(143.3°C)	60 Min.
		Estimated		
B2-1	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
B2-2	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
B2-3	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
B2-4	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
B2-5	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
B2-6	Combustor	1000(537.8°C)	800(426.7°C)	3.5 Hrs.
		Estimated		
B3-1	HPT-Stg.1	1000(537.8°C)	1000(537.8°C)	4.5 Hrs.
B3-2	HPT-Stg.2	950(510.0°C)	1000(537.8°C)	4.5 Hrs.
	C Sump #4 Strut	500-600°F (260.0-315.6°C)		11.0 Hrs.

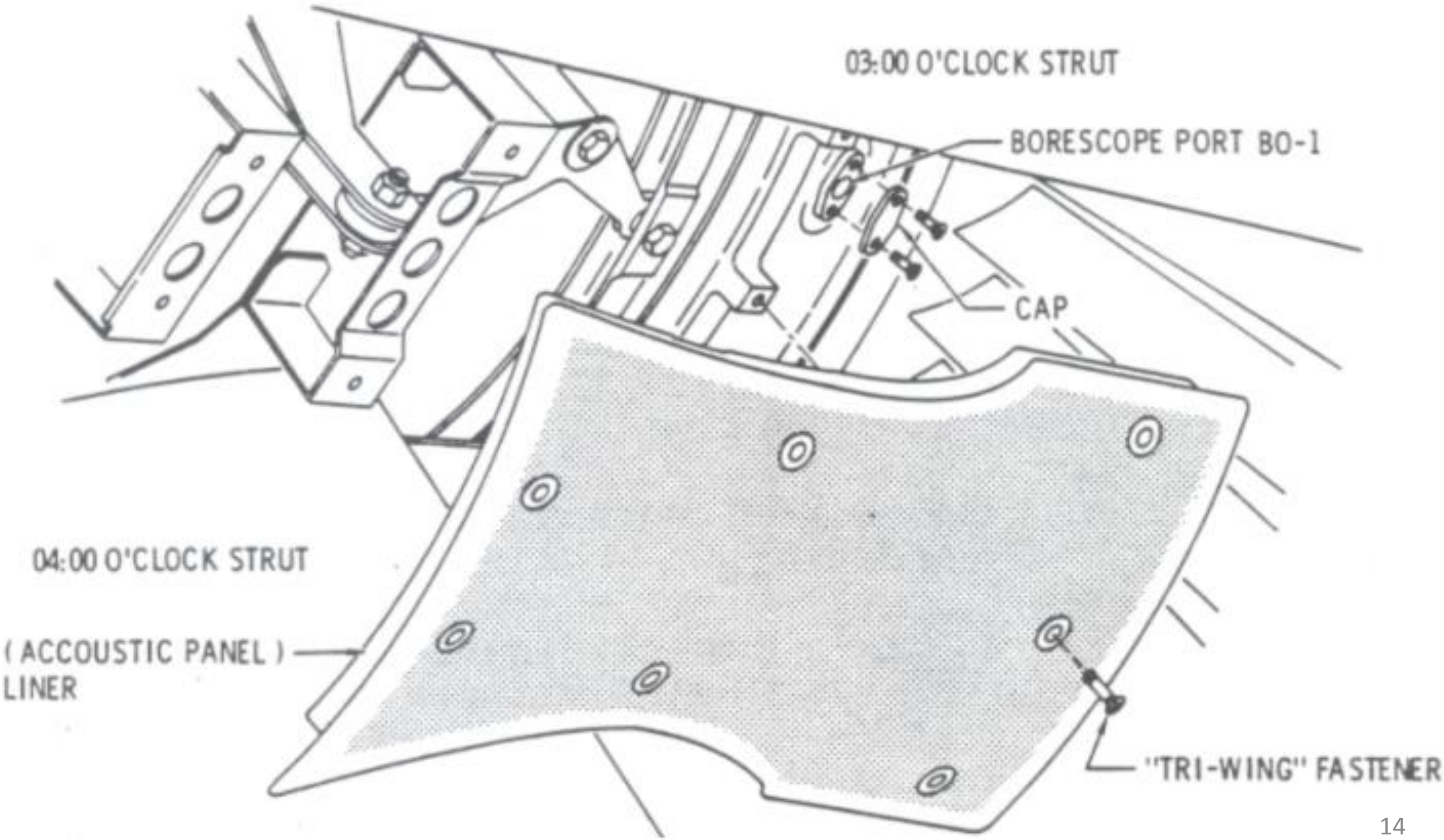
BORESCOPE TEMPERATURE LIMITATIONS

Borescope Port Identification Per NDT Manual	Component Inspected	Gas. Temp. At Ground Idle - F`	Metal Temp At Ground Idle - F`	Without Motoring Time To Reach 100˚F (37.8`C)
B4-1	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-2	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-3	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-4	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-5	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-6	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-7	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-8	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-9	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-10	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-11	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-12	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-13	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-14	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-15	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	4.5 Hrs.
B4-16	LPT - Stg. 1	700(371.1˚C)	1000(537.8˚C)	5.5 Hrs.
		Estimated		
B5-2	LPT - Stg. 2	800(426.7˚C)	900(482.2˚C)	4.0 Hrs.
B5-3	LPT - Stg. 3	800(426.7˚C)	800(426.7˚C)	3.5 Hrs.
B5-4	LPT - Stg. 4	700(371.1˚C)	800(426.7˚C)	3.5 Hrs.
B5-5 Deleted				

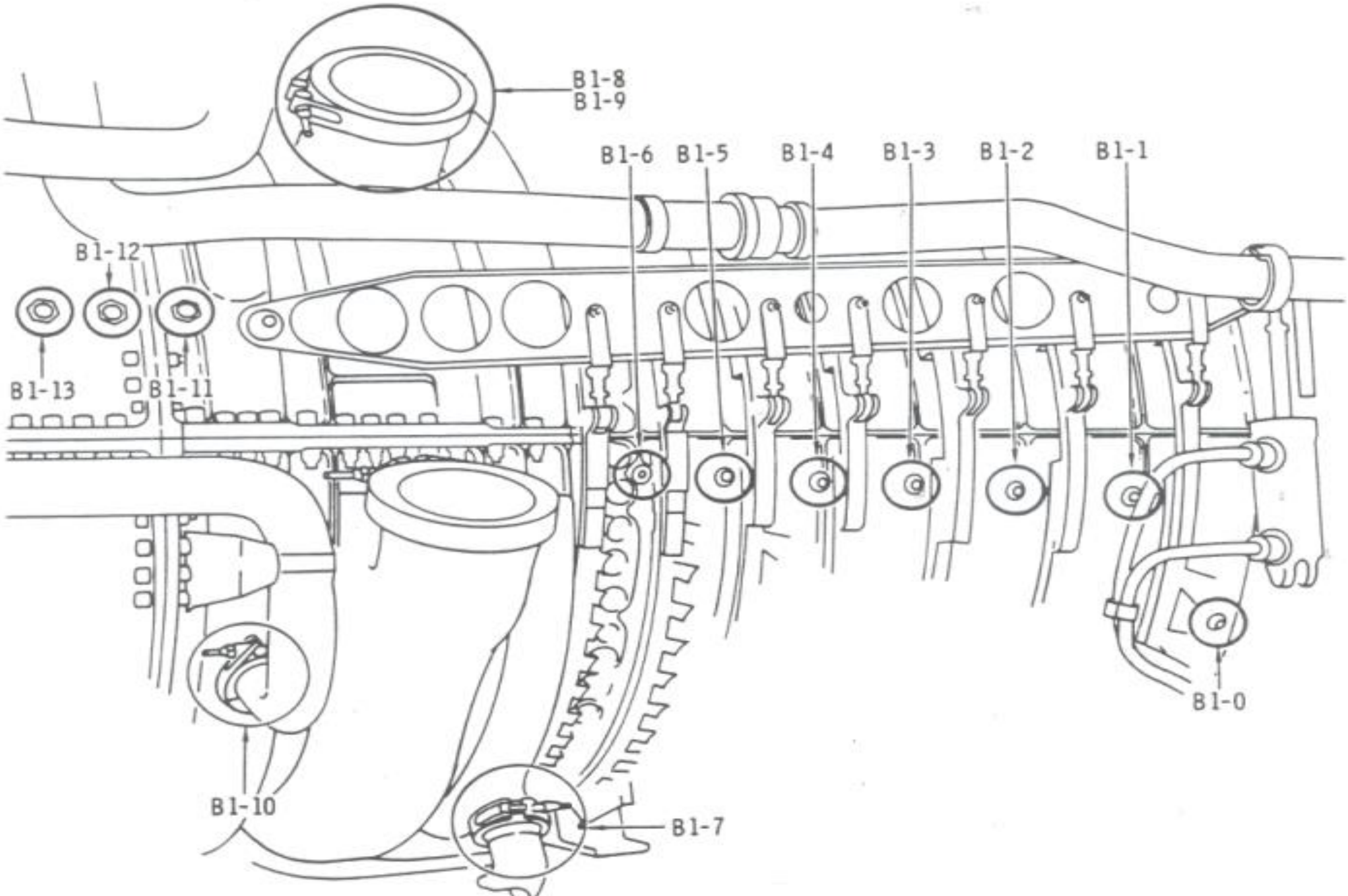
ENGINE ACCESS PORTS



ENGINE ACCESS PORTS – FAN



ENGINE ACCESS PORTS – COMPRESSOR

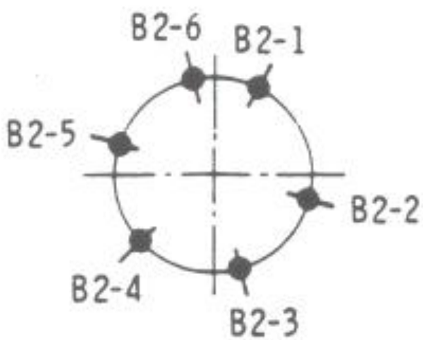


ENGINE ACCESS PORTS – COMPRESSOR

STAGE	NO. OF BLADES	VIEWING LEADING EDGE PORT NO.	VIEWING TRAILING EDGE PORT NO.
1	36	B1-0	B1-1
2	26	B1-1	B1-2
3	42	B1-2	B1-3
4	45	B1-3	B1-4
5	48	B1-4	B1-5
6	54	B1-5	B1-6
7	56	B1-6	B1-7
8	64	B1-7	B1-8
9	66	B1-8	B1-9
10	66	B1-9	B1-10
11	76	B1-10	B1-11
12	76	B1-11	B1-12
13	76	B1-12	B1-13
14	76	B1-13	------

ENGINE ACCESS PORTS – COMBUSTION CHAMBER

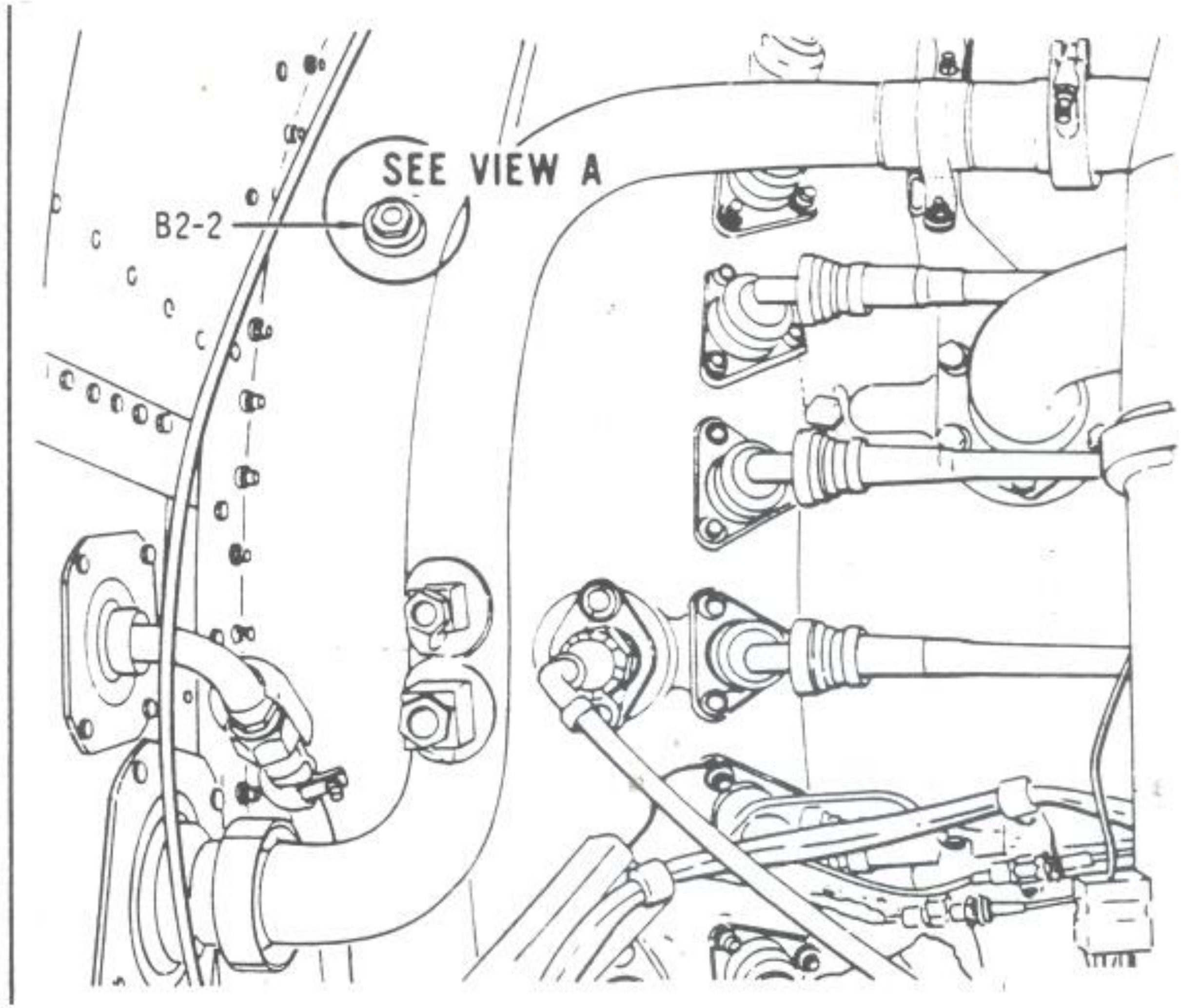
CIRCUMFERENTIAL PORT LOCATION



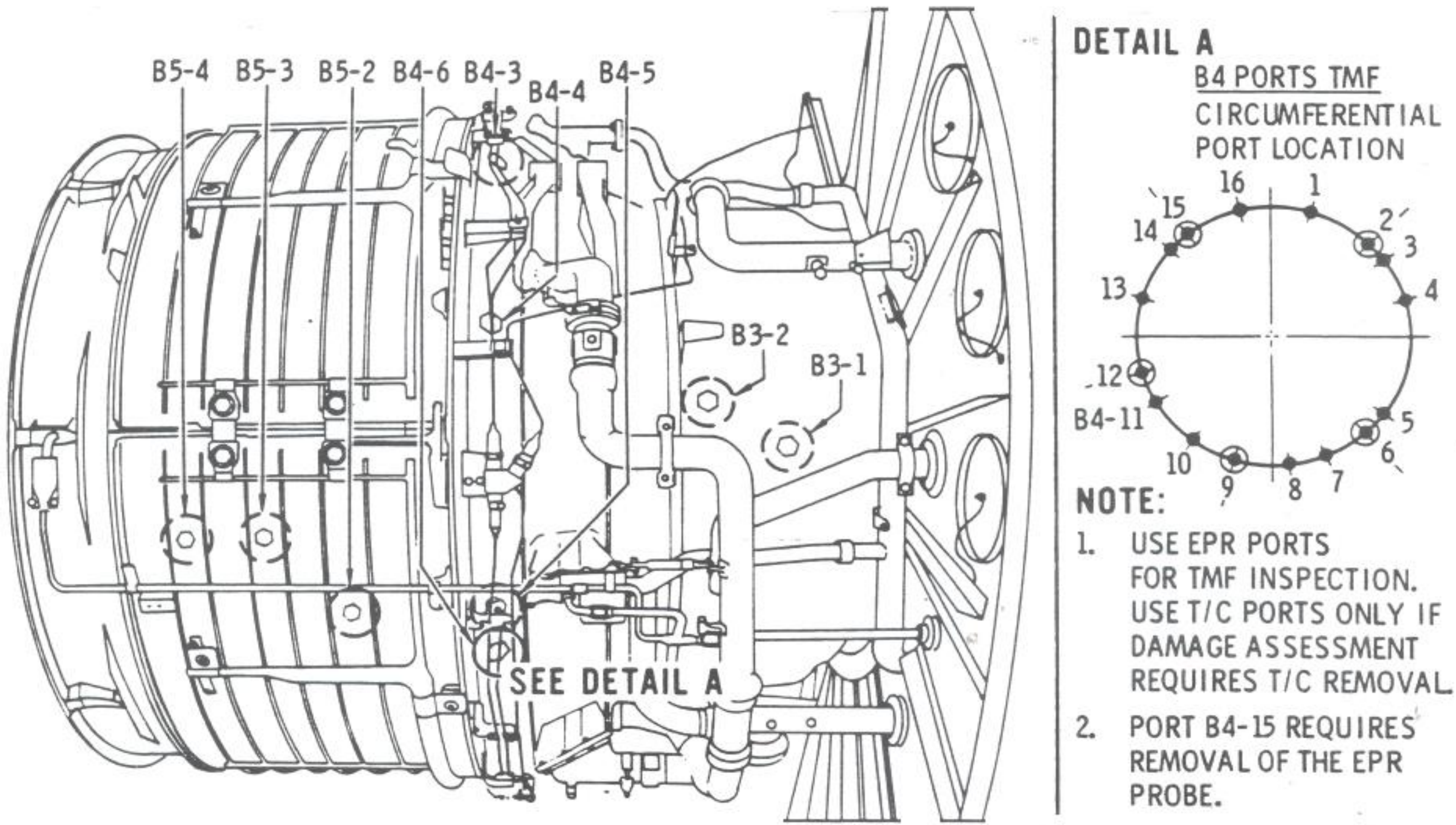
LOOKING FORWARD

NOTE:

PORT B2-6
IS NOT ACCESSIBLE
ON SOME B747
INSTALLATIONS



ENGINE ACCESS PORTS – TURBINE



ENGINE ACCESS PORTS – TURBINE

HIGH-PRESSURE TURBINE SECTION

STAGE	NO. OF BLADES	VIEWING LEADING EDGE PORT NO.	VIEWING TRAILING EDGE PORT NO.
1	80	B3-1	B3-2
2	74	B3-2	-----

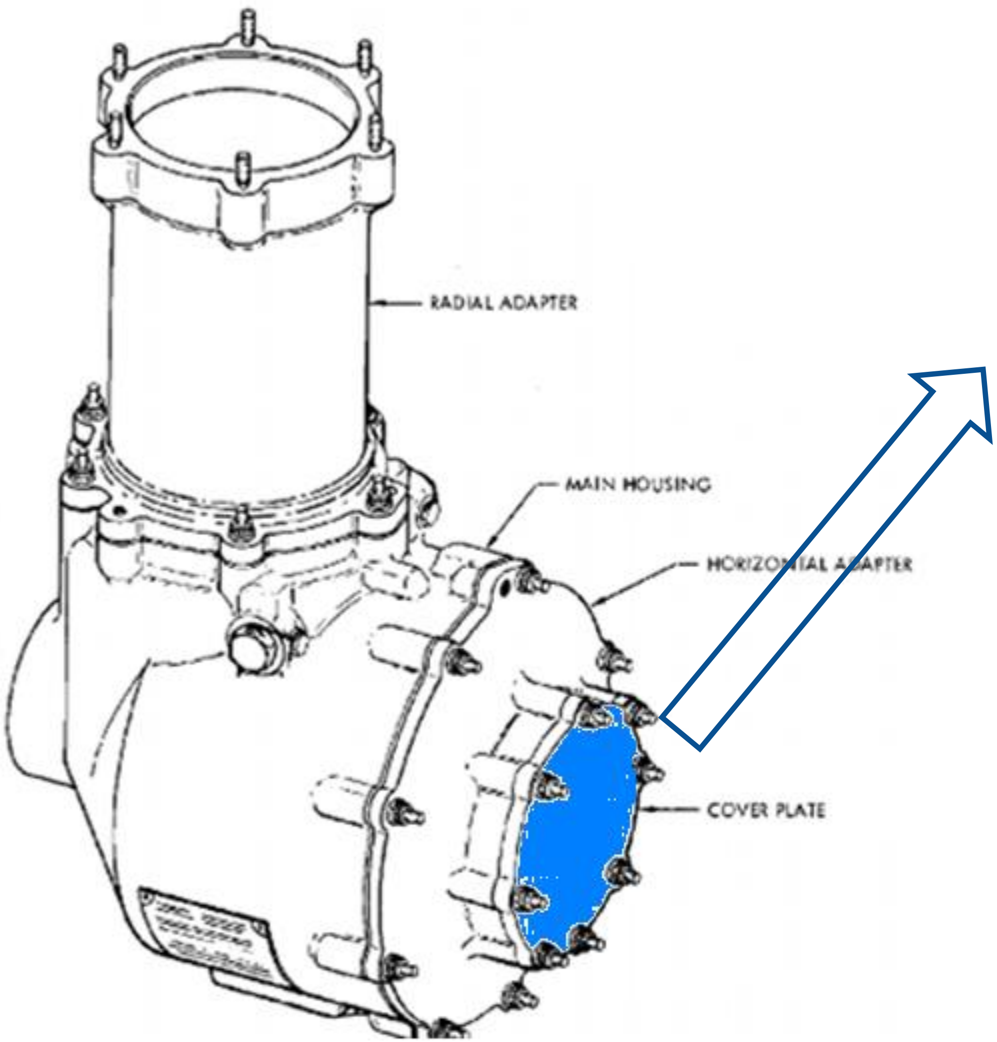
TURBINE MID FRAME AREA

VIEWING AREA PER PORT	TOTAL PORTS
INNER AND OUTER LINERS STRUT LINER	16 (B4-1 THRU B4-16)

LOW-PRESSURE TURBINE SECTION

STAGE	NO. OF BLADES	VIEWING LEADING EDGE PORT NO.	VIEWING TRAILING EDGE PORT NO.
1	128	B4-6	B5-2
2	126	B5-2	B5-3
3	112	B5-3	B5-4
4	86	B5-4	-----

CORE ROTOR ZERO INDEX



This is the place where the protractor will be installed .

A ¾ inch square-drive receptacle is available for direct insertion of a torque handle, after removing the transfer gear box aft cover plate

The ratio between gearbox and Core engine is 0.956.

CORE ROTOR ZERO INDEX

1. Core rotation is obtained by inserting a ¾ inch (19.05) square drive wrench into the transfer gearbox. The wrench should be turned slowly as the ratio between the transfer gearbox and the core is 0.956; one

2. A protractor is used for setting up a zero reference for the compressor and high-pressure turbine rotor, and subsequently defining the angular position an thus the blade number of any damaged blade

3. Easy manual turning of the core rotor, permits viewing of all rotor blades in any stage. **The zero indexing procedure provides a method to relocate a specific blade in a given stage for evaluation of serviceable damage or deterioration after selected intervals of operation**. The rotor zero-reference procedure is recommended when serviceable defects are observed with any borescope equipment

CORE ROTOR ZERO INDEX - PROCEDURE

1. Insert the borescope in the port B1-11, and view aft to the 12^{th} stage of the compressor rotor blade platform.

2. Rotate the transfer gearbox, counterclockwise until the 1^{st} blade slot locking-lug appears in the field of view of the borescope. Compressor rotor blades rotate clockwise as viewed through borescope.

3. Continue to rotate until the 2^{nd} locking lug appears.

4. Position the next blade in rotation until it is in line with the leading edge of the stage 12 compressor stator blade as viewed through the scope. This is blade No 1 and blade No 2 .will appear next

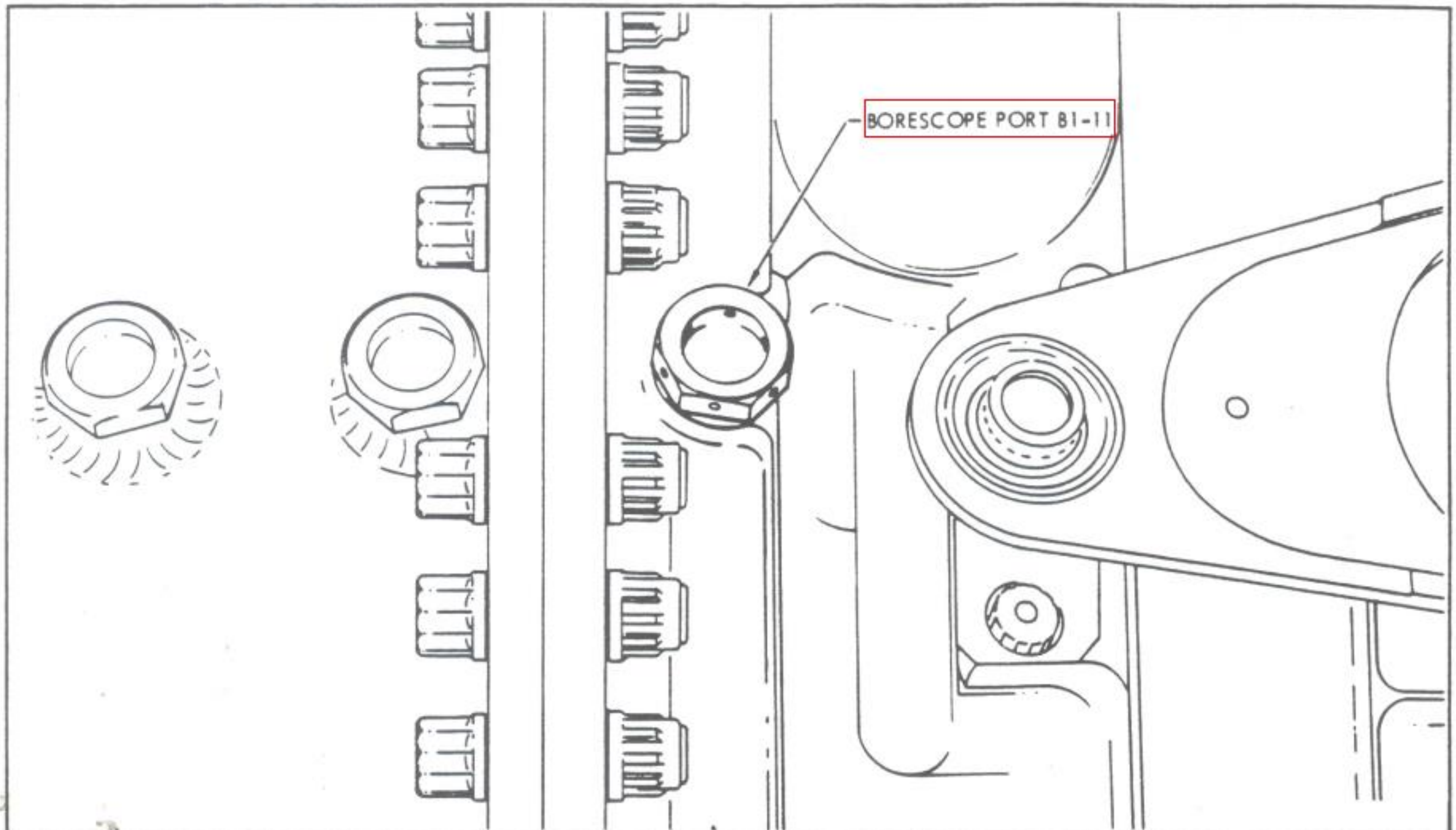
CORE ROTOR ZERO INDEX - PROCEDURE

5. Position pointer on the protractor to zero degrees

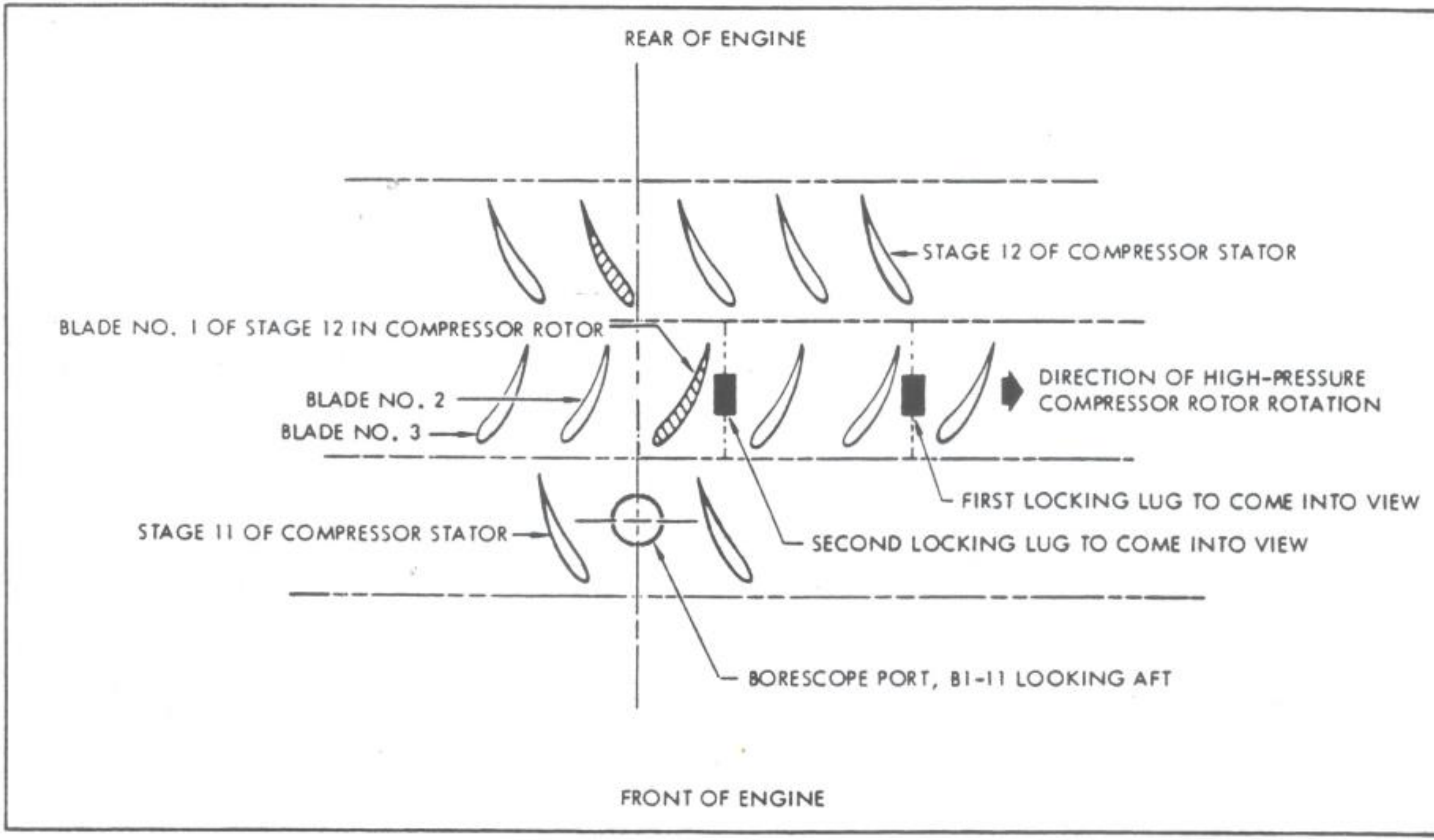
6. The core engine rotor is now zero-referenced for all stages of the compressor and the 2 high pressure turbine rotor stages. The inspection of each stage must commence with the core rotor positioned back to the zero reference point at stage 12.

7. Because of gear ratio difference between transfer gear box and core rotor, stop core rotation at 344 degrees indicated protractor angle, and reset protractor pointer pointer to zero. The reset is required after each position. To minimize accumulated error, repeat steps 1 through 5 after 8 rotations.

CORE ROTOR ZERO INDEX - PROCEDURE



CORE ROTOR ZERO INDEX - PROCEDURE



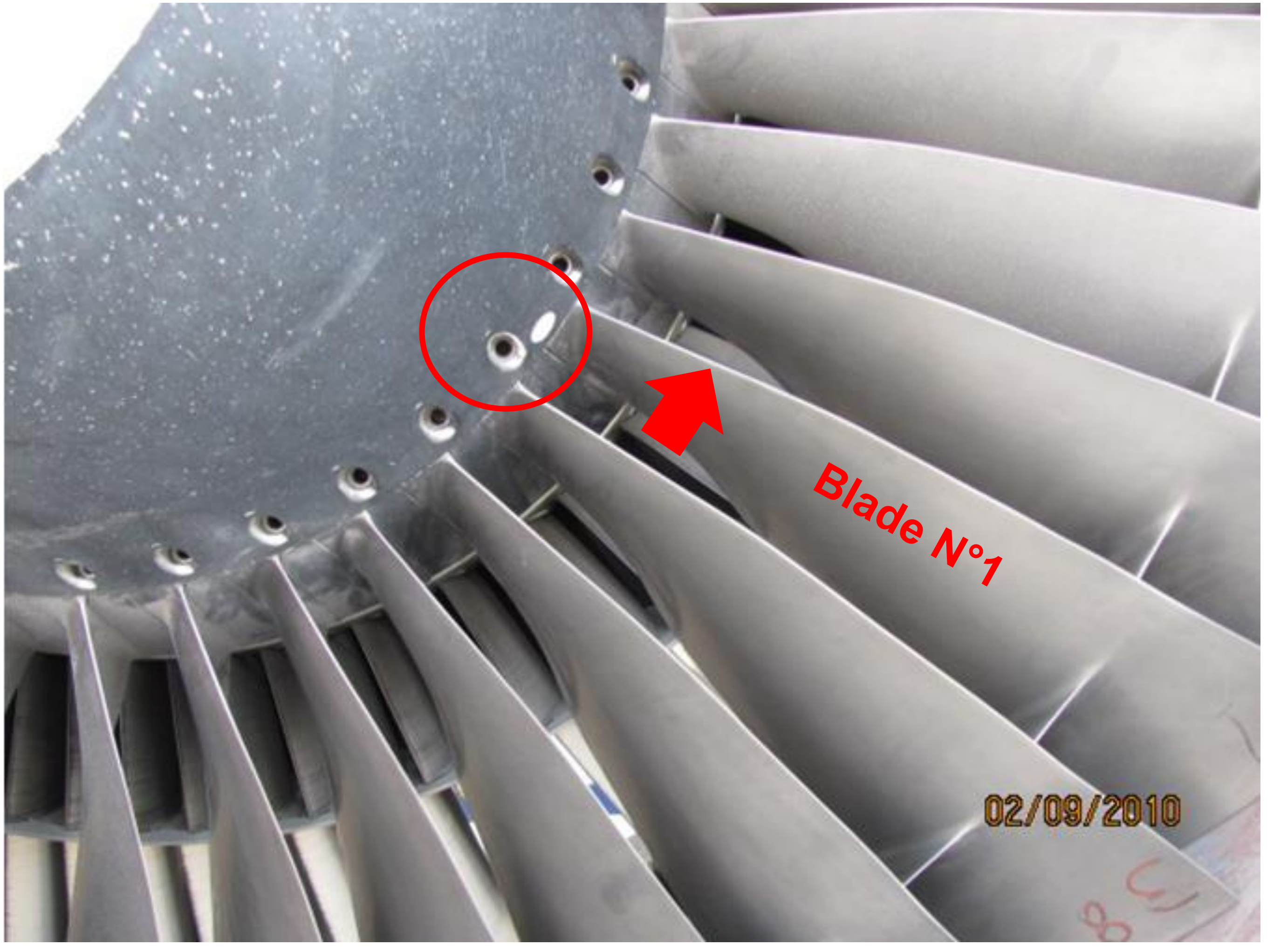
FAN ROTOR ZERO INDEX - PROCEDURE

When damage is observed in low pressure turbine rotor components, establish the low pressure turbine rotor zero-reference as follows:

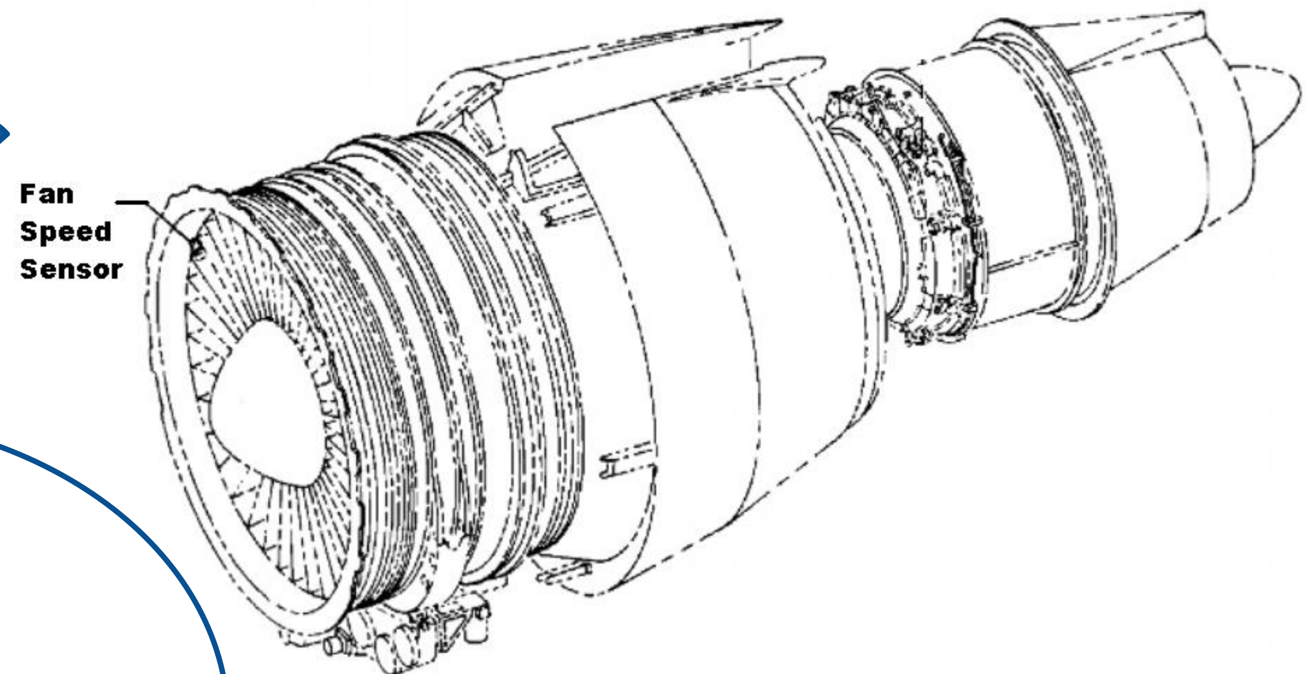
1. Zero index the fan rotor. Align spinner match mark(offset hole) with two o' clock fan speed sensor, aft looking forward.
2. Find the blade to the left of the match mark on the fan spinner
3. Align the leading edge of this blade with the top edge of the 2 o' clock fan speed sensor.
4. Insert the borescope in port B4 – 6. Position the probe to view aft. The blade in view will be blade number one
5. Rotate the fan rotor counterclockwise aft looking forward
6. Record damage as directed

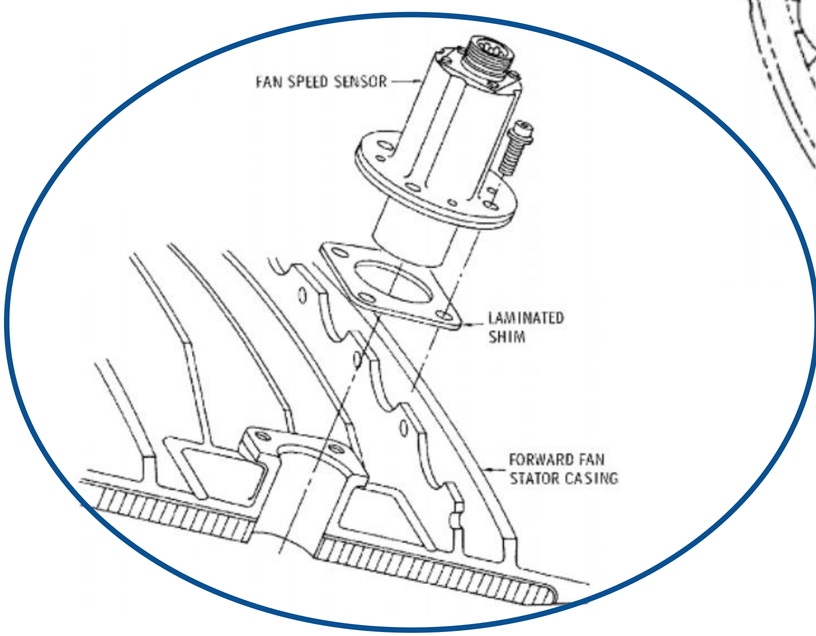
FAN ROTOR ZERO INDEX - PROCEDURE

The offset hole in the spinner (painted white) and the offset hole of the disk (marked "OS" or painted white) are located in the same position. If the white mark is not found, the spinner has to be removed in order to find the “OS” mark.

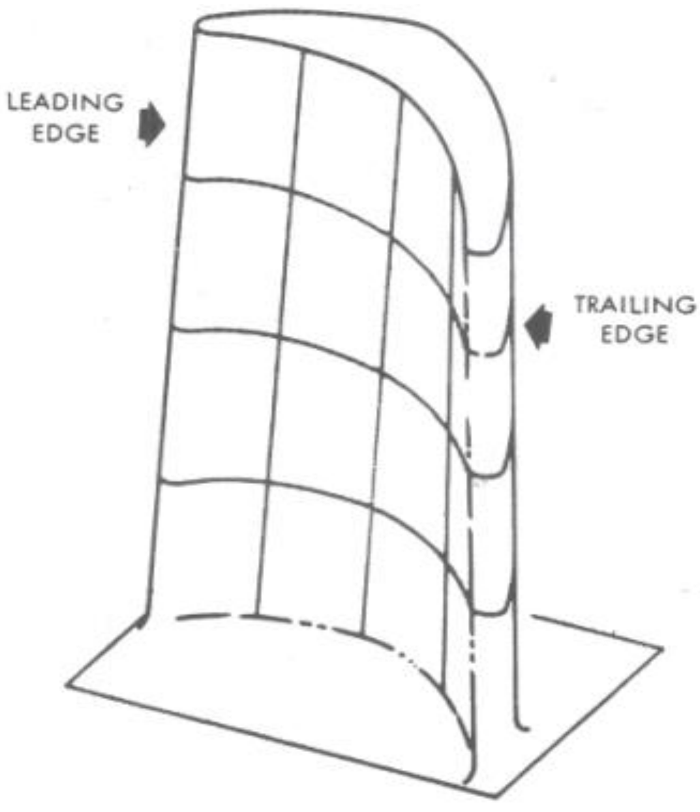


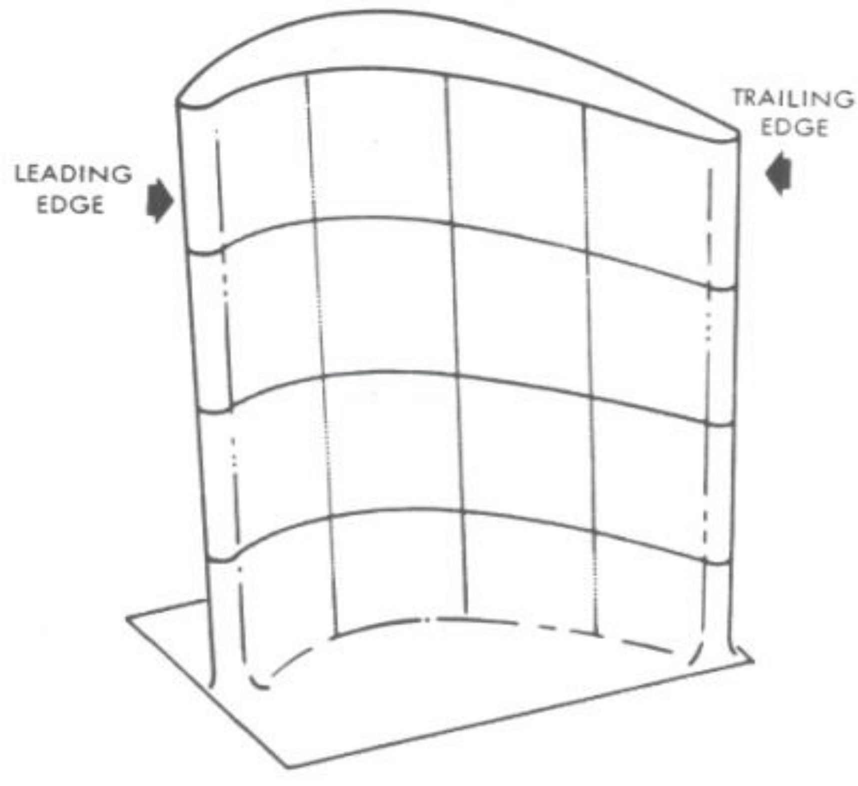
FAN ROTOR ZERO INDEX - PROCEDURE





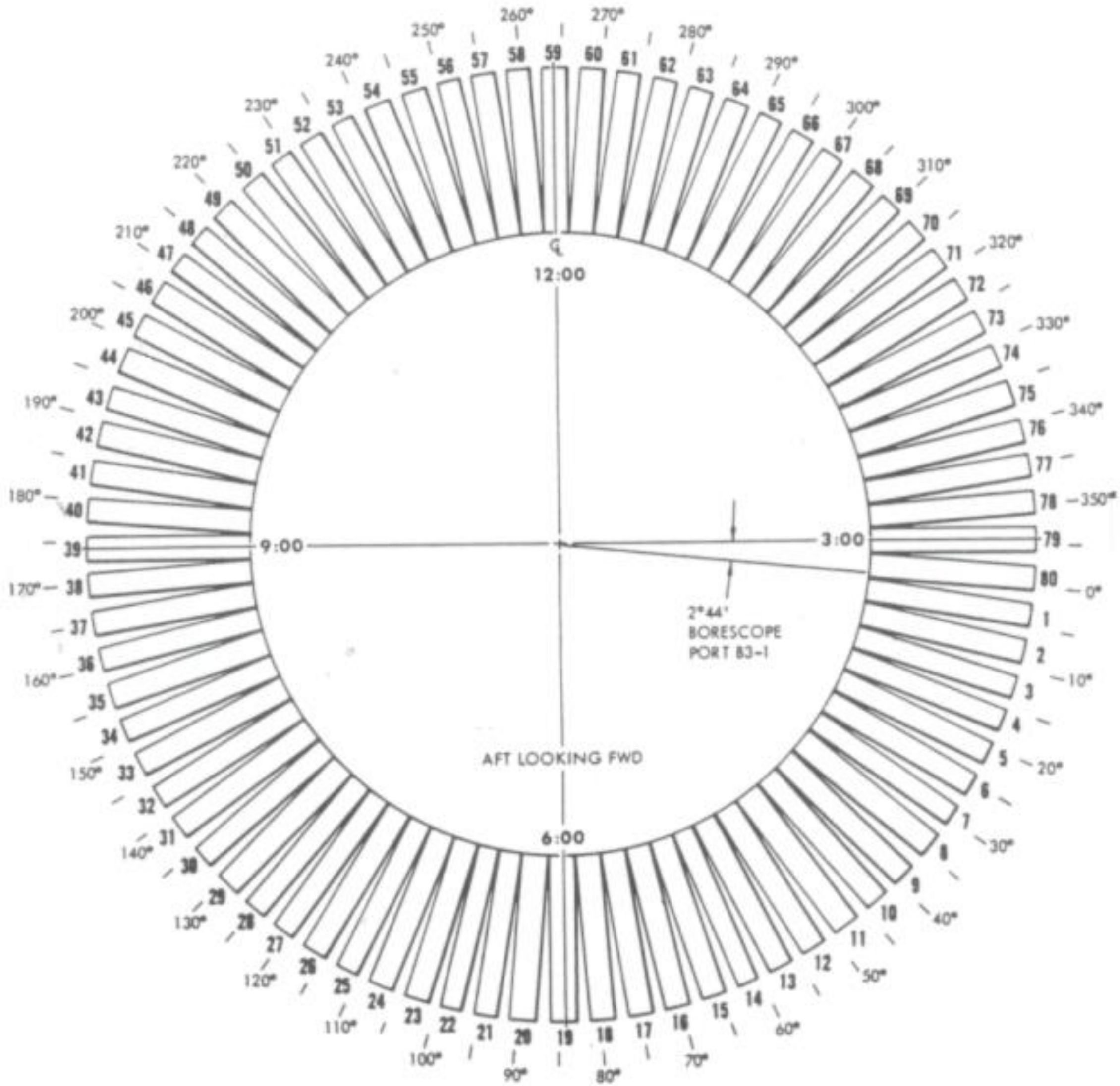
BORESCOPE REPORTS - EXAMPLES





In this graphic you will have to draw any damage that it will be found on the blades

BORESCOPE REPORTS - EXAMPLES

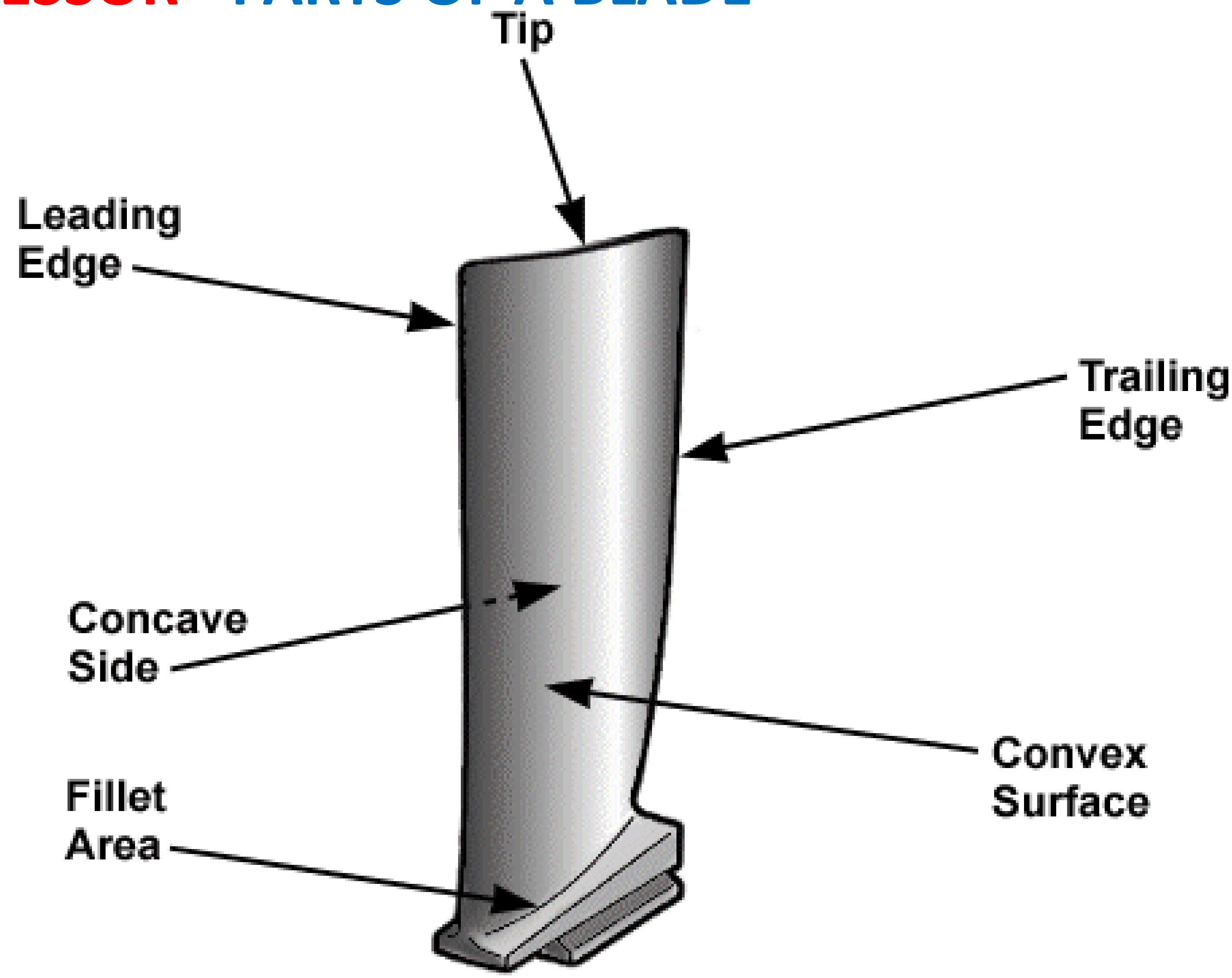


In this graphic you will mark all blades that are found damaged

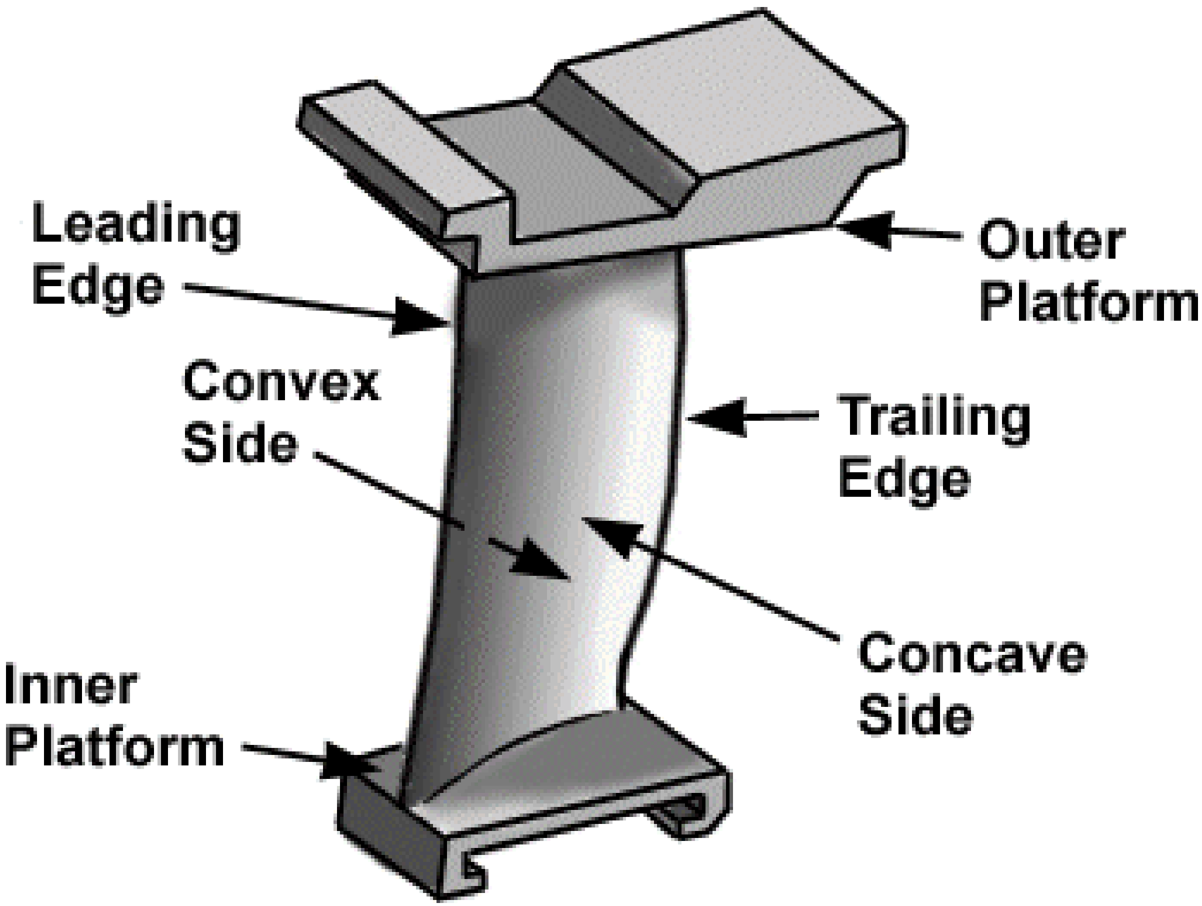
BORESCOPE REPORTS - EXAMPLES

IV. HIGH PRESSURE TURBINE					
HPT STAGE	BORESCOPE PORT		N° OF BLADES	INSPECTOR	RESULTS
	L/E	T/E			
1	B3-1		80		
1		B3-2			
2	B3-2		74		
2		-----			

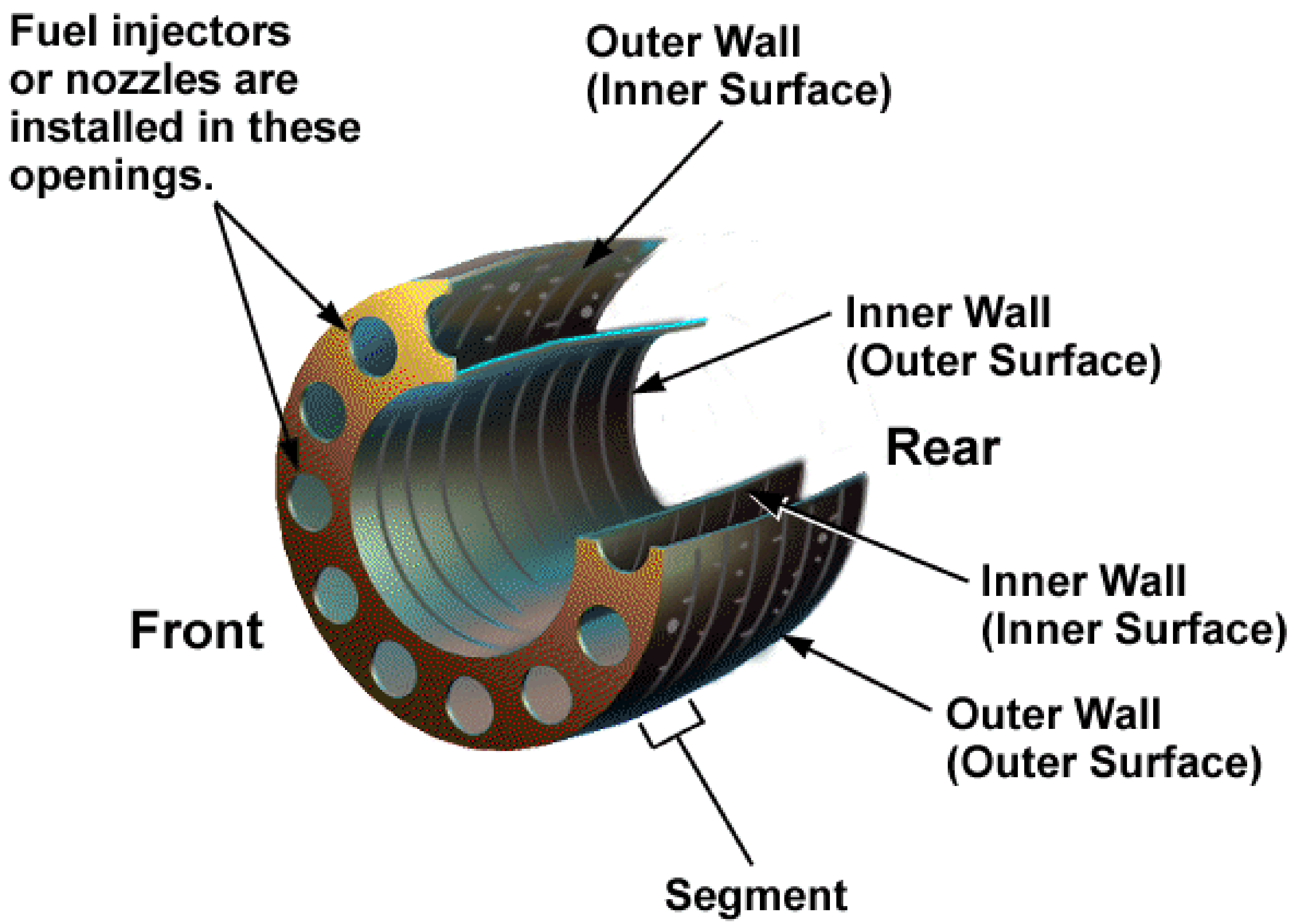
COMPRESSOR - PARTS OF A BLADE



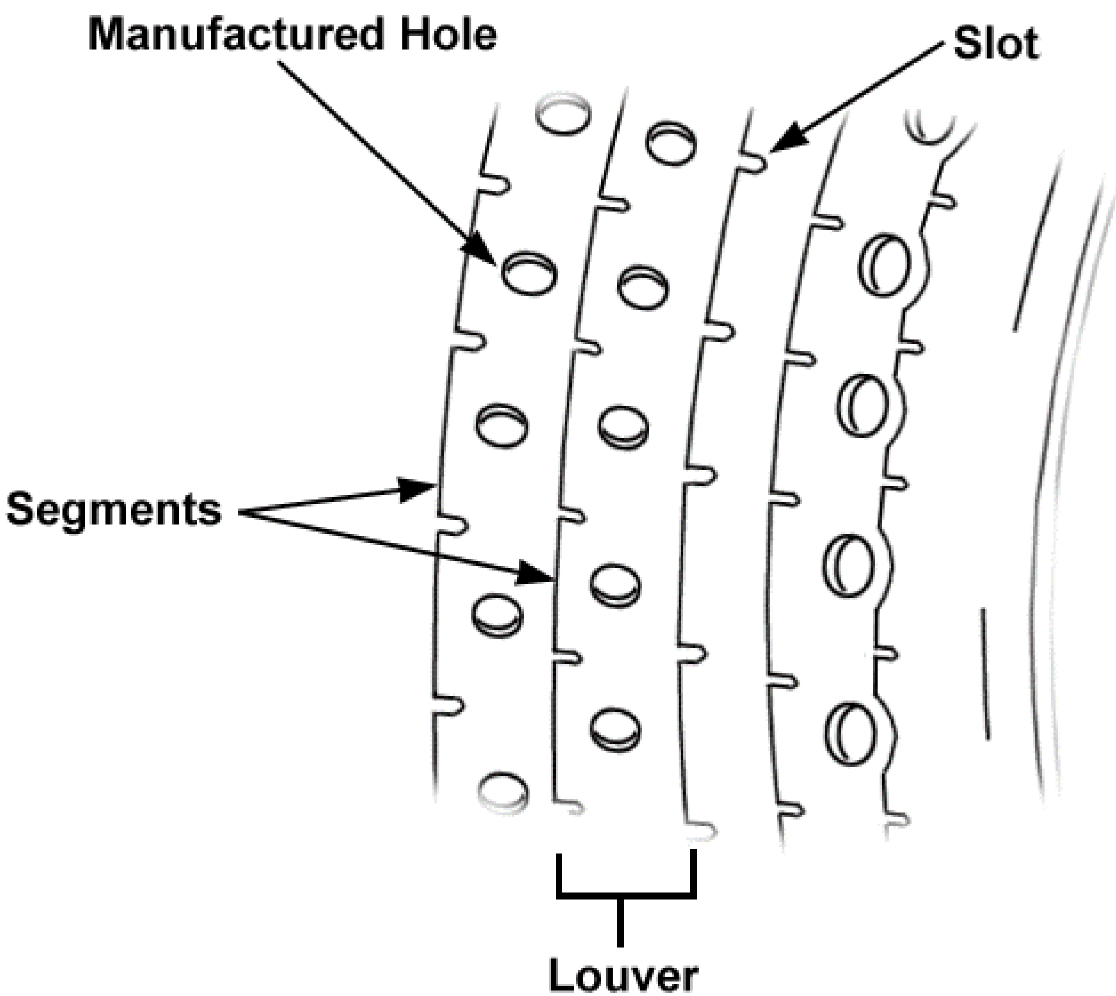
COMPRESSOR - PARTS OF A VANE



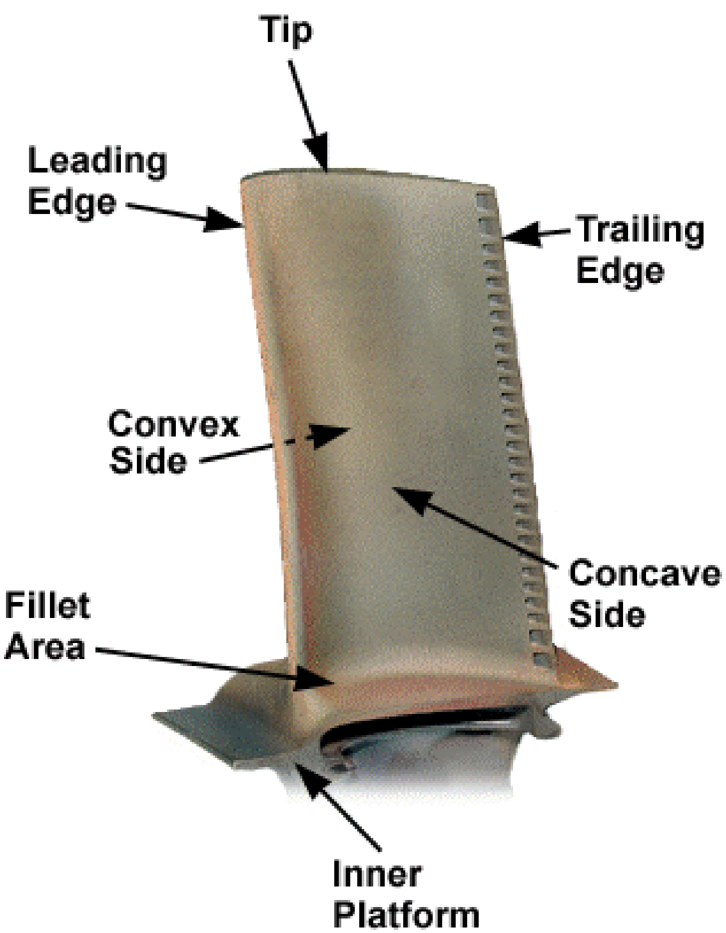
COMBUSTION CHAMBER - PARTS



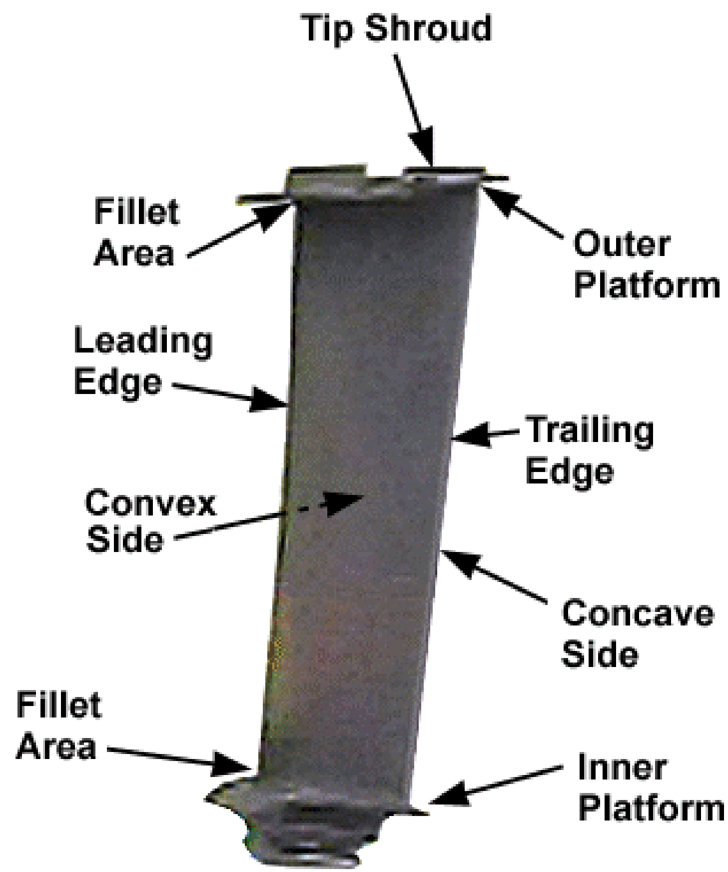
COMBUSTION CHAMBER - PARTS



TURBINE – PARTS OF A BLADE

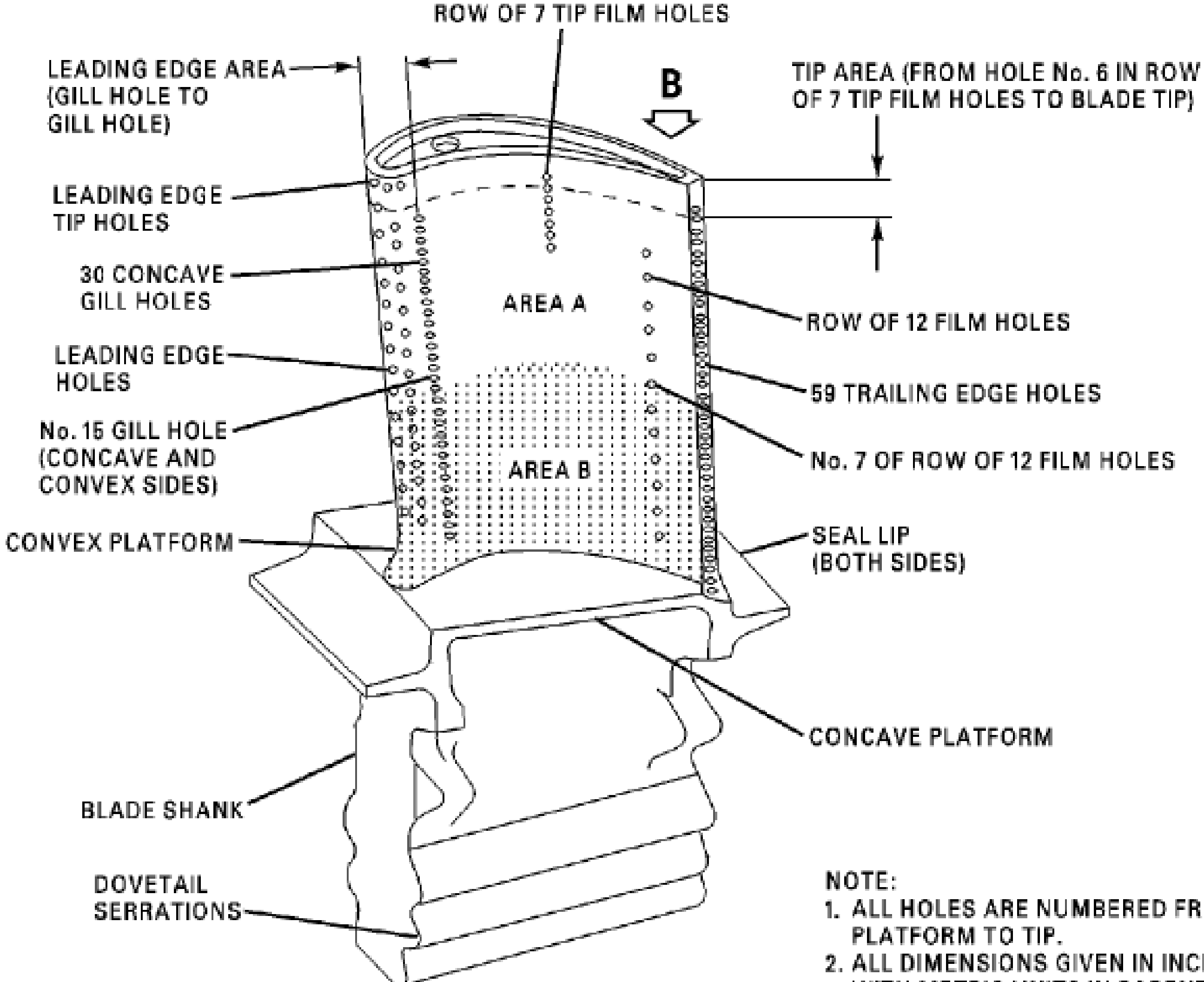


Nonshrouded Blade



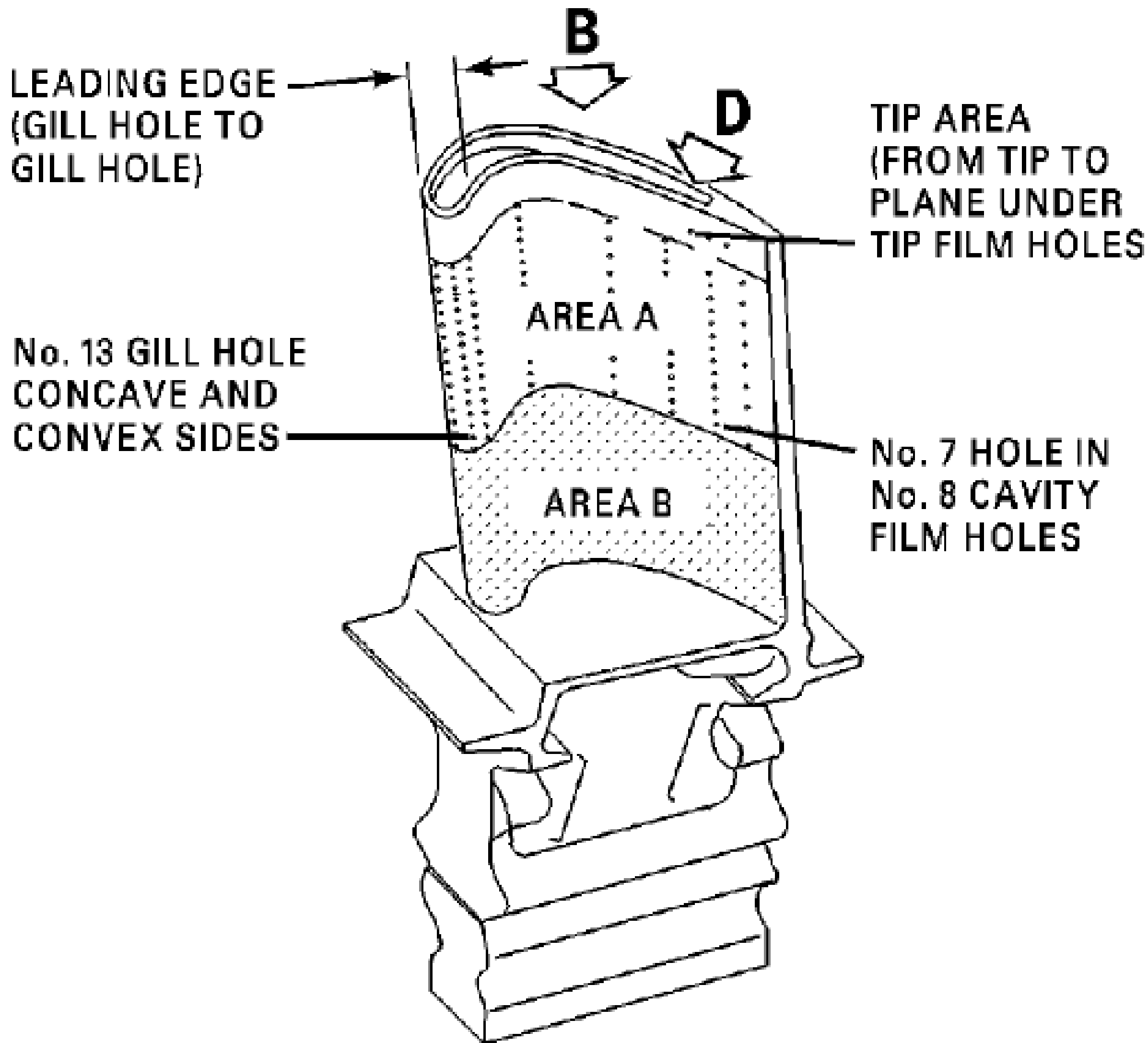
Shrouded Blade

HPTR - STAGE 1 BLADE – CONFIGURATION 3

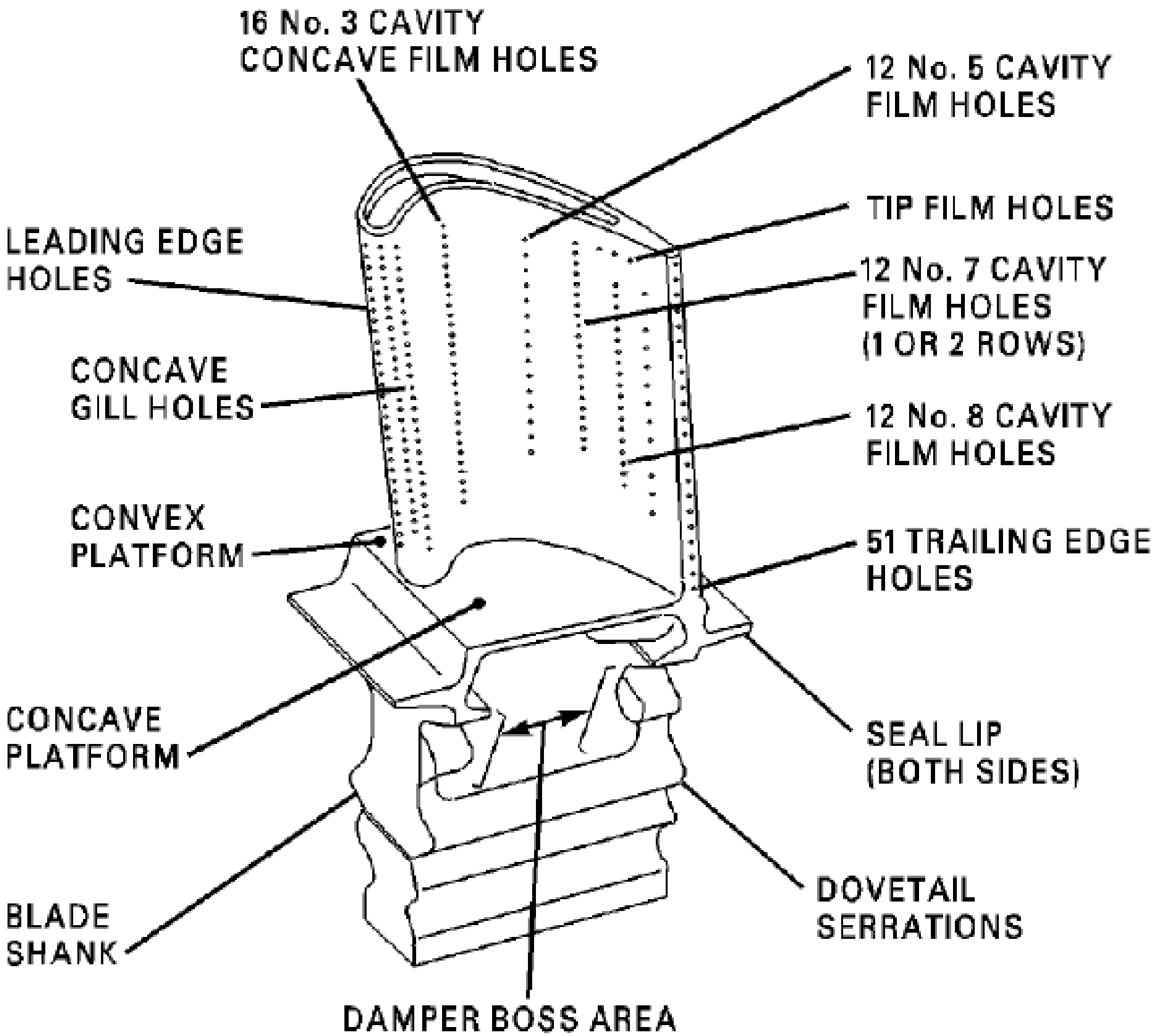


NOTE:
1. ALL HOLES ARE NUMBERED FROM PLATFORM TO TIP.
2. ALL DIMENSIONS GIVEN IN INCHES WITH METRIC UNITS IN PARENTHESES.

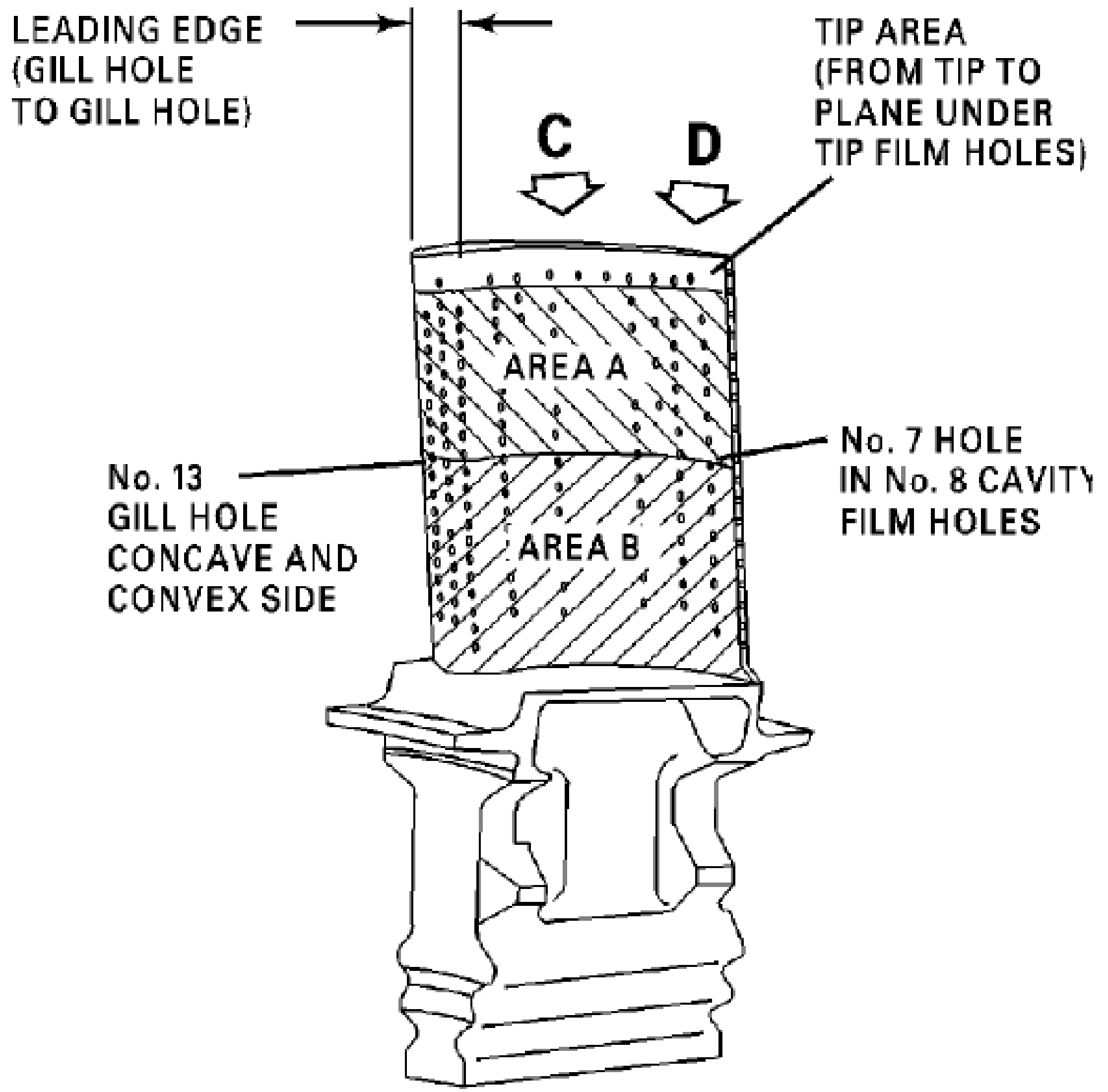
HPTR - STAGE 1 BLADE – CONFIGURATION 4



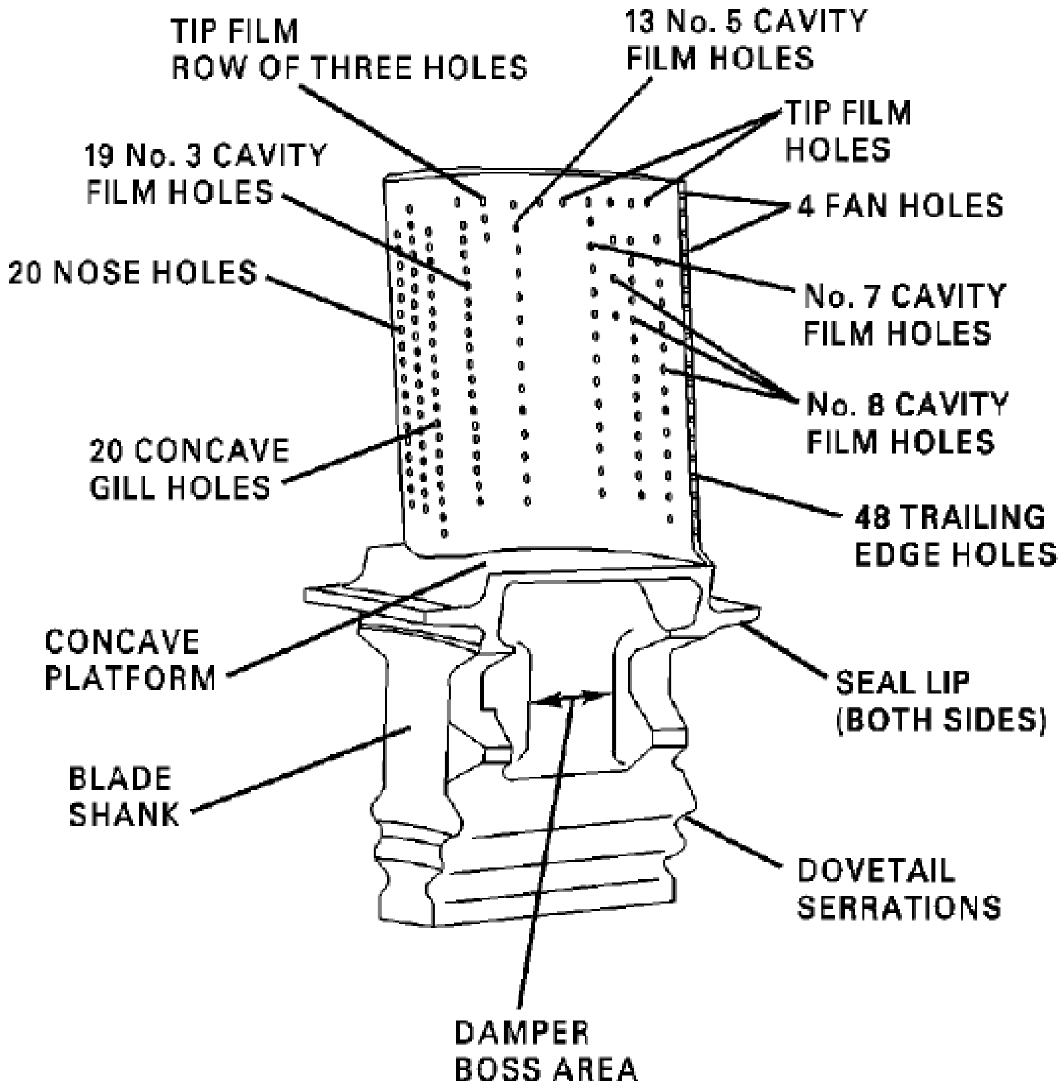
HPTR - STAGE 1 BLADE – CONFIGURATION 4



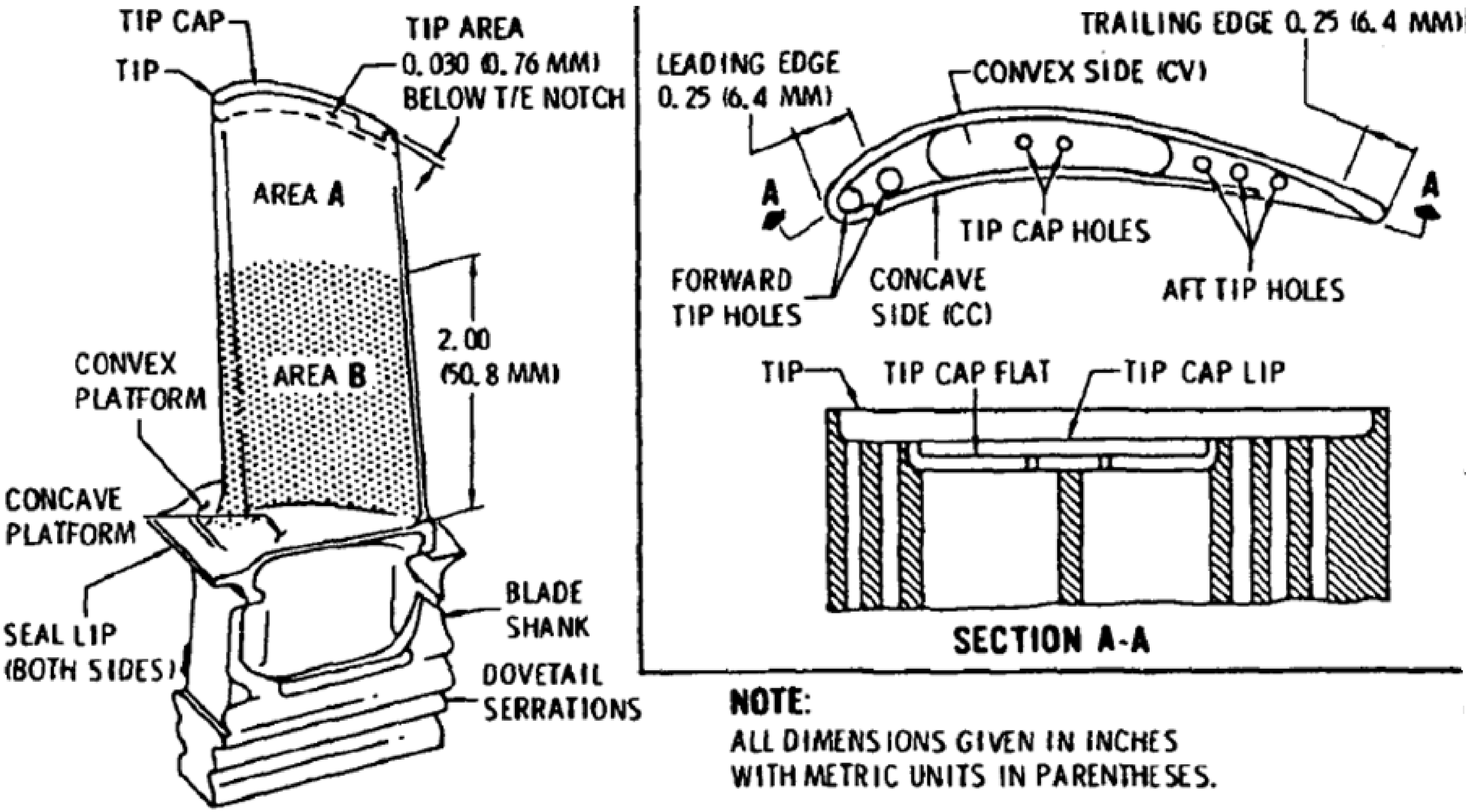
HPTR - STAGE 1 BLADE – CONFIGURATION 5



HPTR - STAGE 1 BLADE – CONFIGURATION 5

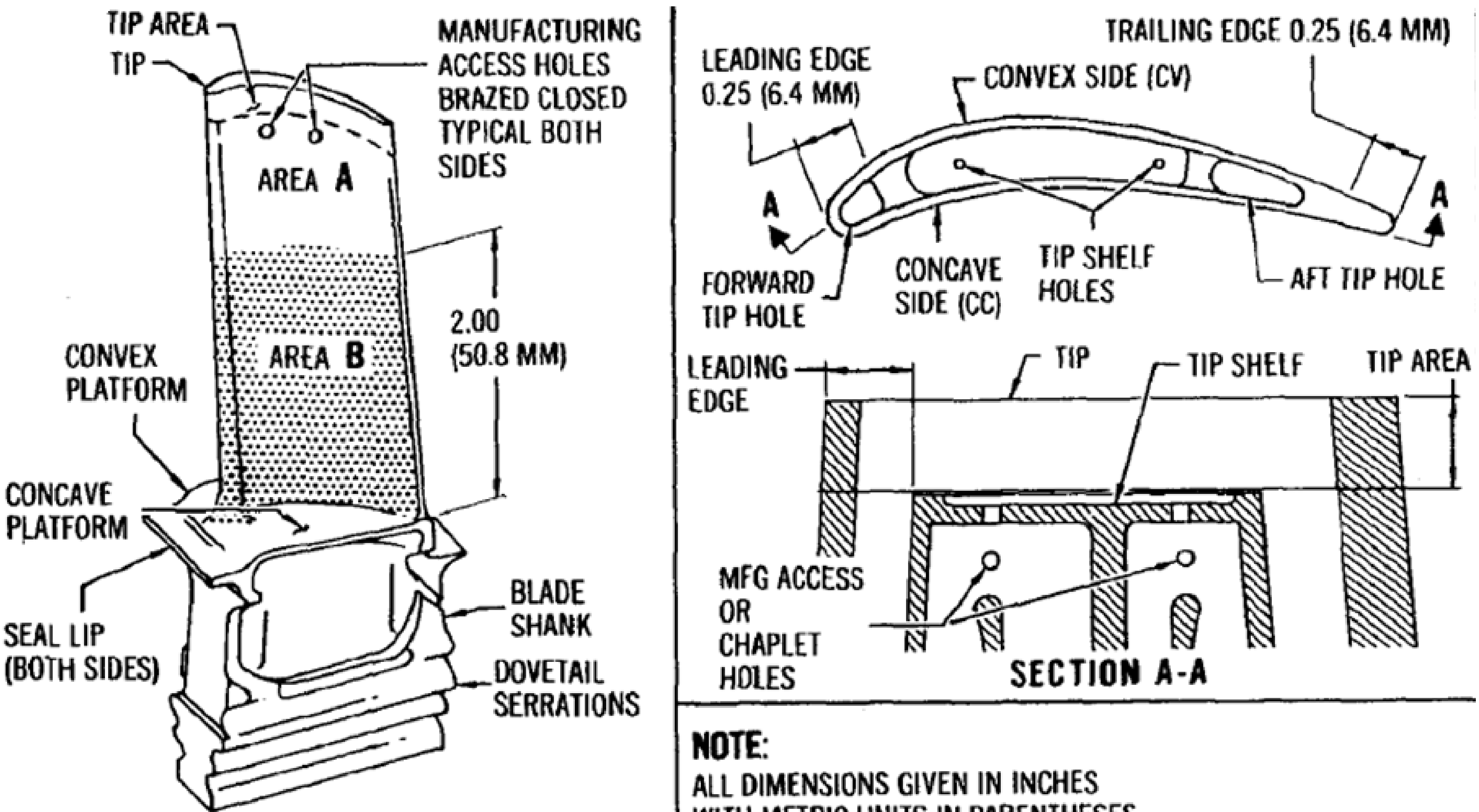


HPTR - STAGE 2 BLADE – CONFIGURATION 1



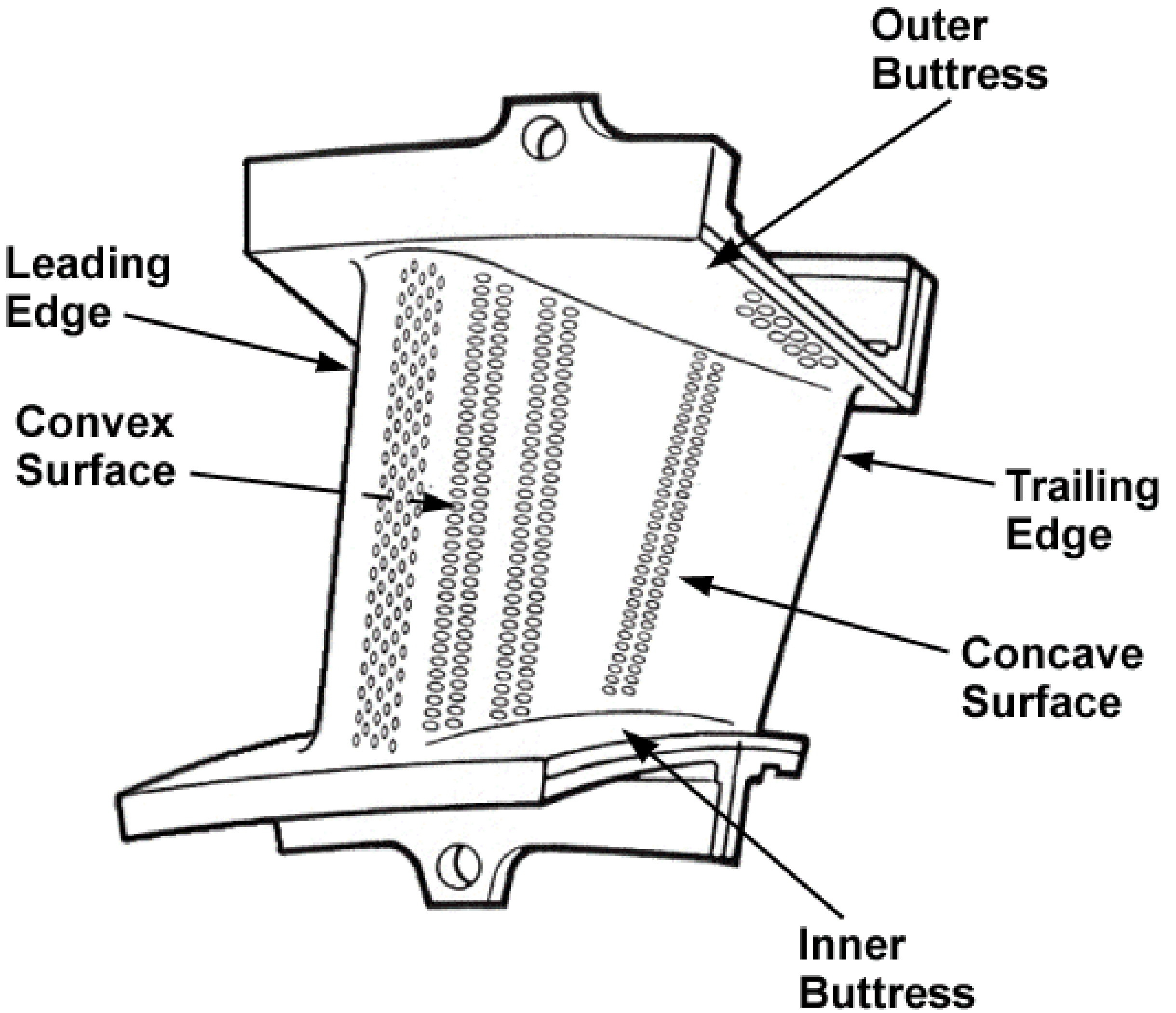
NOTE:
ALL DIMENSIONS GIVEN IN INCHES
WITH METRIC UNITS IN PARENTHESES.

HPTR - STAGE 2 BLADE – CONFIGURATION 2



NOTE:
ALL DIMENSIONS GIVEN IN INCHES WITH METRIC UNITS IN PARENTHESES.

TURBINE – PARTS OF A VANE



CAUSES OF DAMAGE

Causes of Damage and Engine Sections Where Each Type of Damage Typically Occurs

	Foreign Objects	Mechanical Stresses	High Temperatures	Chemical Effects
Compressor (incl. Fan)	●	● ①	○	○
Combustor	○	○	●	●
Turbine	○	● ①	●	● ②

Legend:

● This cause of damage typically affects this engine section.

○ This cause of damage seldom (or very seldom) affects this section.

Notes:

① Mechanical stresses tend to cause more distress on blades than on vanes.

② Chemical effects tend to cause more damage on vanes than on blades.

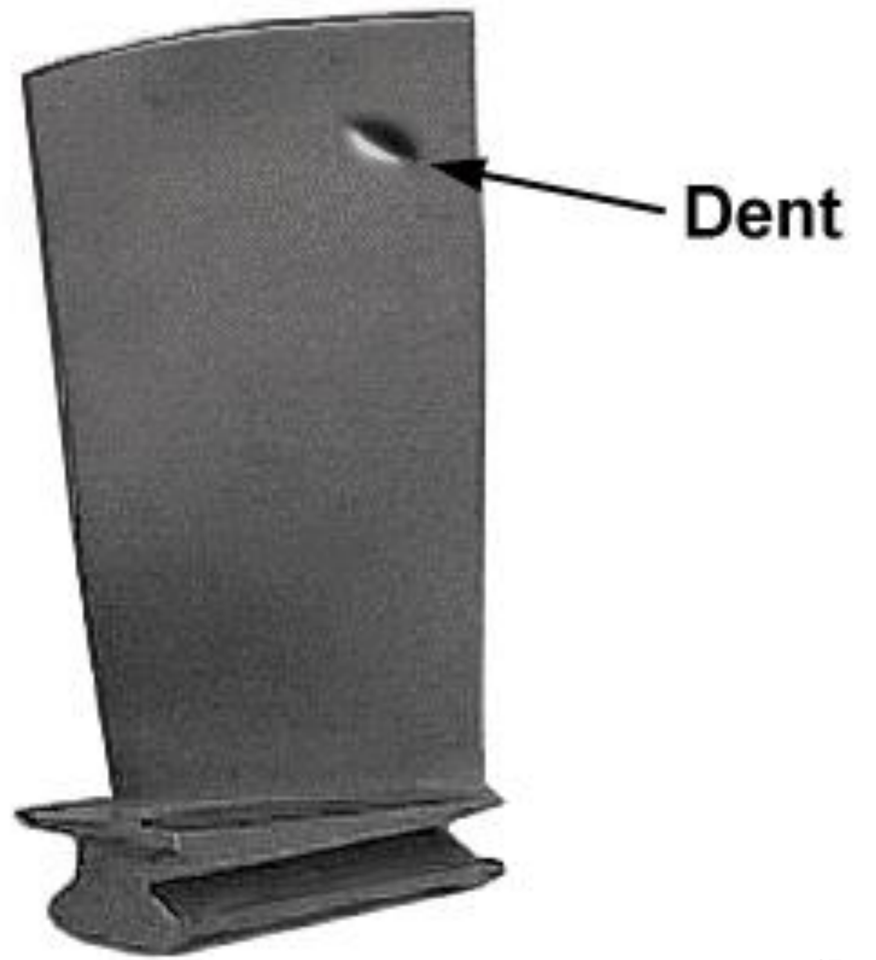
TYPES OF DAMAGE

TYPES OF DAMAGE	COMPRESSOR	COMBUSTION CHAMBER	TURBINE
DENTS	X		
NICKS	X		
CRACKS	X	X	X
EROSION	X	X	X
TIP ABRASION	X		
BURNING		X	X
BURN STREAK		X	
MISSING MATERIAL		X	X
COKING		X	
SULFIDATION			X
ESTRUCTURAL DEFORMATION			X
CLOGGED COOLING AIR HOLES			X

TYPES OF DAMAGE - COMPRESSOR

a) DENTS

A dent is a depression or indentation in the blade's surface. The bottom of a dent is rounded, not sharp; however, some dents are dep and rough. Dents can occur anywhere on a blade.

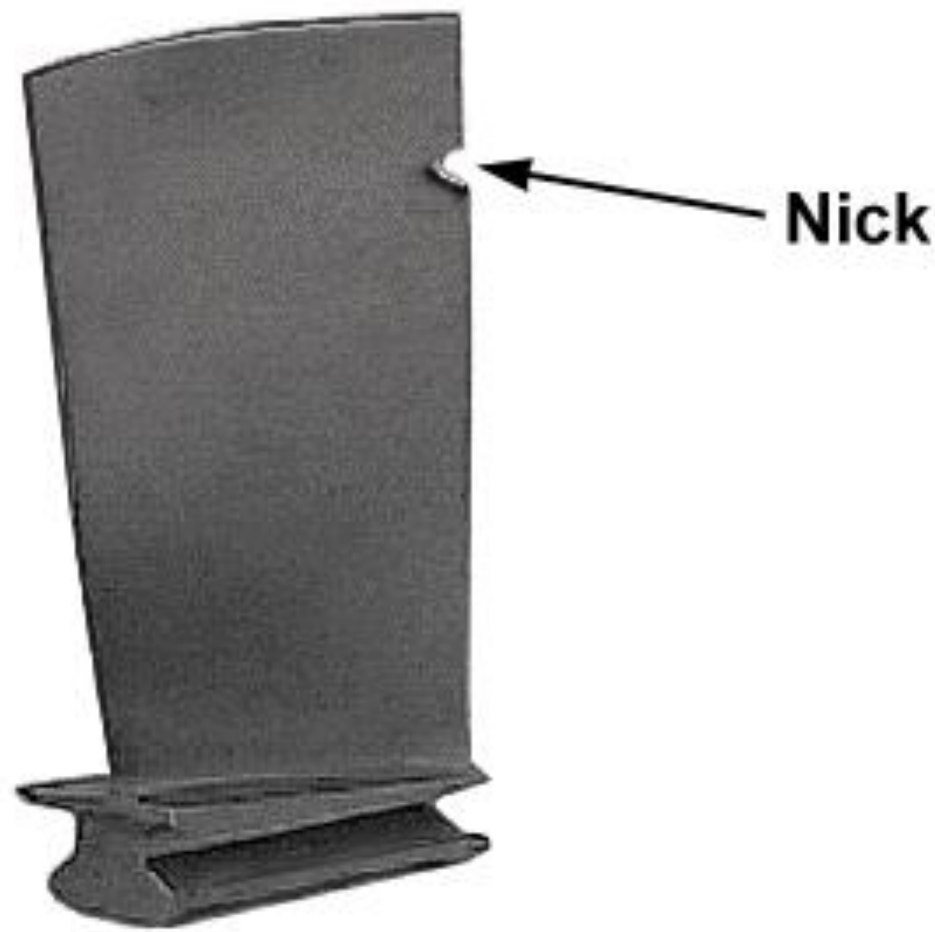


TYPES OF DAMAGE - COMPRESSOR

b) NICKS

A nick is a small sharp-bottom notch ,slit ,cut , or identation. Nicks usually occur on the leading edge of a blade, but they can also occur anywhere on its surface or trailing edge.

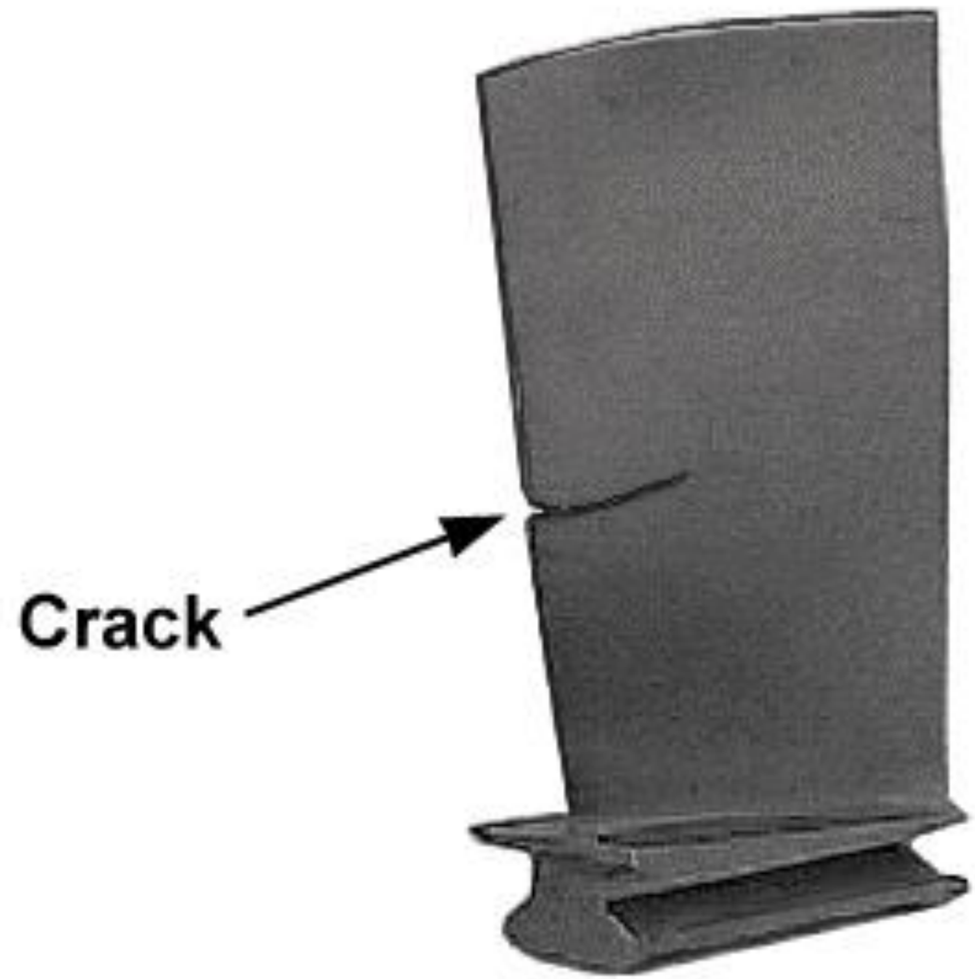
NOTE: it is important to know the difference between a nick and a dent because the mechanical stresses in a blade can cause a nick to become a crack . A nick has sharper edges and sharply angled bottom; a dent is a more blunt and round displacement of material.



TYPES OF DAMAGE - COMPRESSOR

c) CRACKS

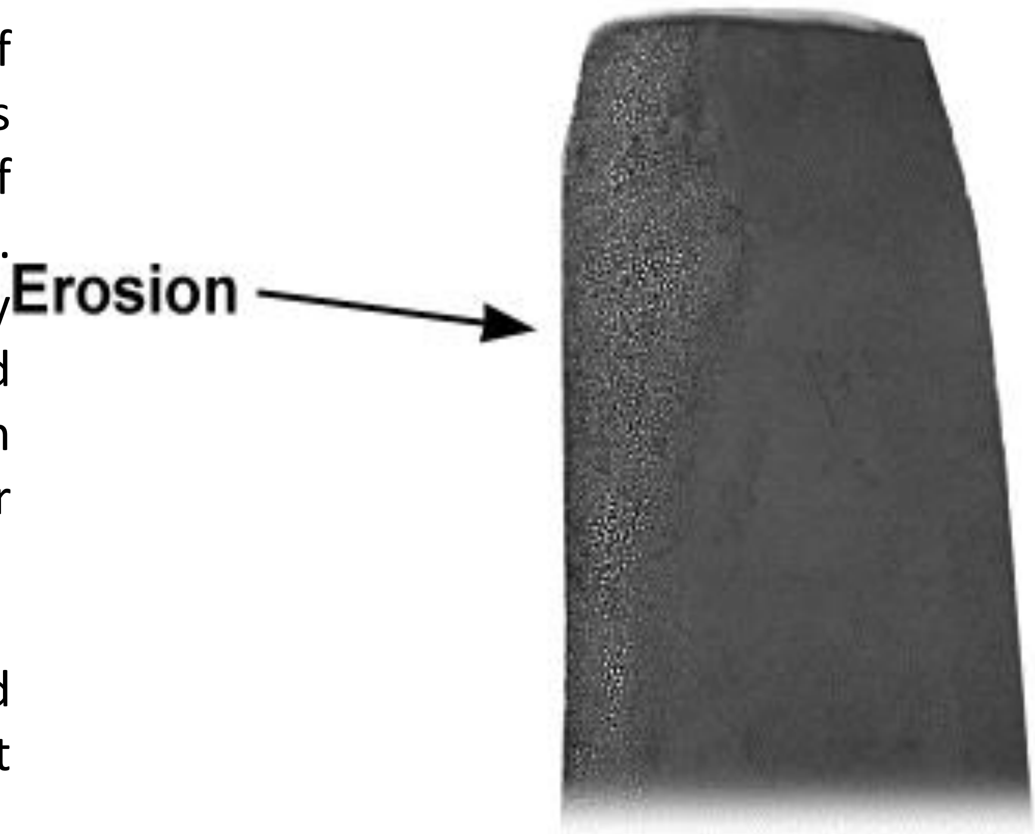
A crack is a narrow opening where the material has separated . Cracks are usually unacceptable on a compressor blade because the fast rotational speeds cause a strong outwards stress that makes the crack grow larger.



TYPES OF DAMAGE - COMPRESSOR

d) EROSION

Erosion is a gradual abrading of the blade surface wich is caused by the impact of materials such as salt and sand. This type of damage is usually on the leading edges and concave surfaces of the fan blades and other compressor stages.

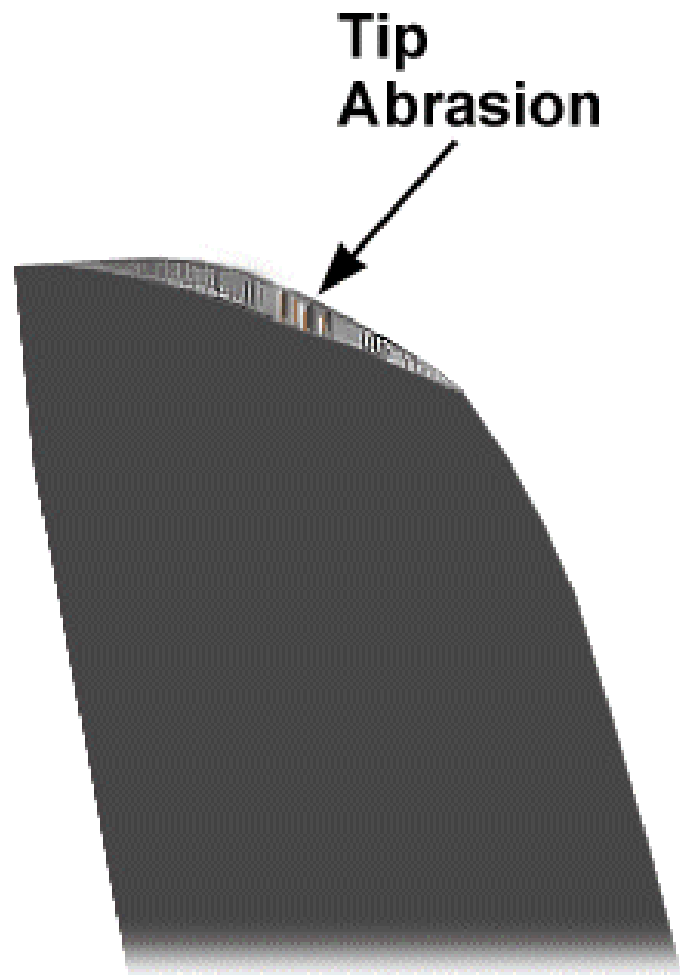


NOTE: erosion is a mild and gradual form of foreign object damage

TYPES OF DAMAGE - COMPRESSOR

e) TIP ABRASION

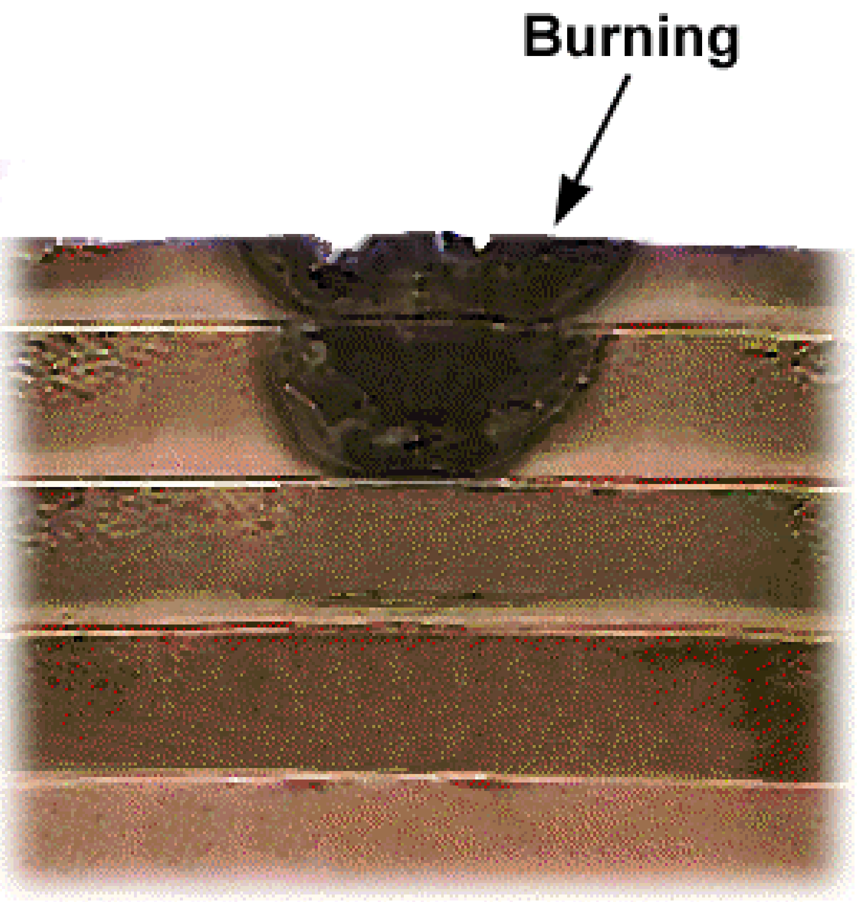
Tip abrasion is the loss of material that occurs when the blade tip rubs against the inner surfaces of he case which may have seals or rub strips. This can happen to fan blades, and it can also happen to other compressor stages.



TYPES OF DAMAGE – COMBUSTION CHAMBER

f) BURNING

Burning is a discoloration or distortion which is caused when excessively high temperatures are concentrated on an area of the combustion chamber wall



TYPES OF DAMAGE – COMBUSTION CHAMBER

g) BURN STREAK

A burn streak is burning that occurs on several adjacent segments, in an axial direction.

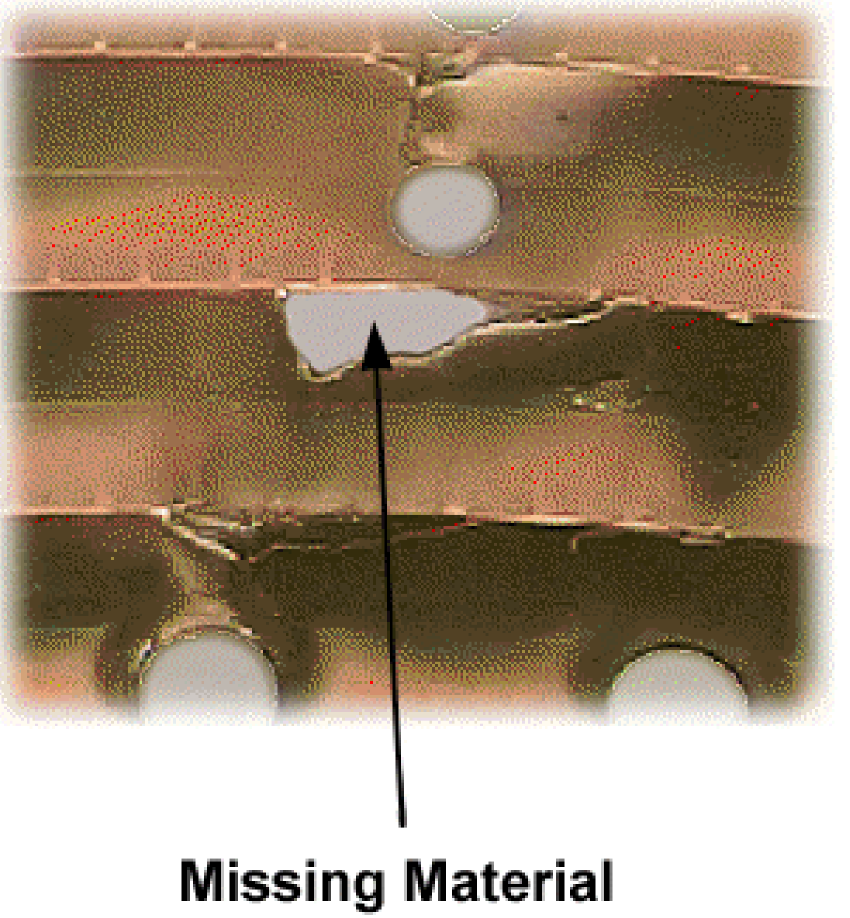
TYPES OF DAMAGE – COMBUSTION CHAMBER

h) MISSING MATERIAL

Missing material is the absence of part of the combustion chamber wall .

It occurs when the burning of material progresses to the point of complete penetration. This is referred to as burn through

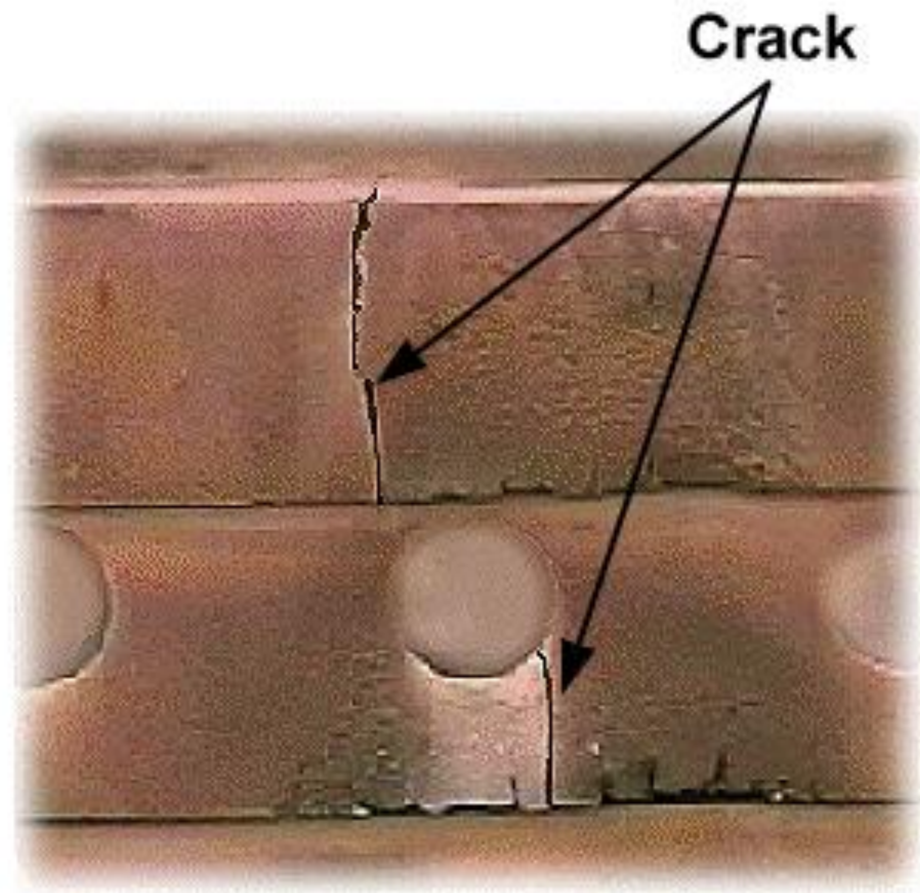
Converging cracks cause material to break



TYPES OF DAMAGE – COMBUSTION CHAMBER

i) CRACK

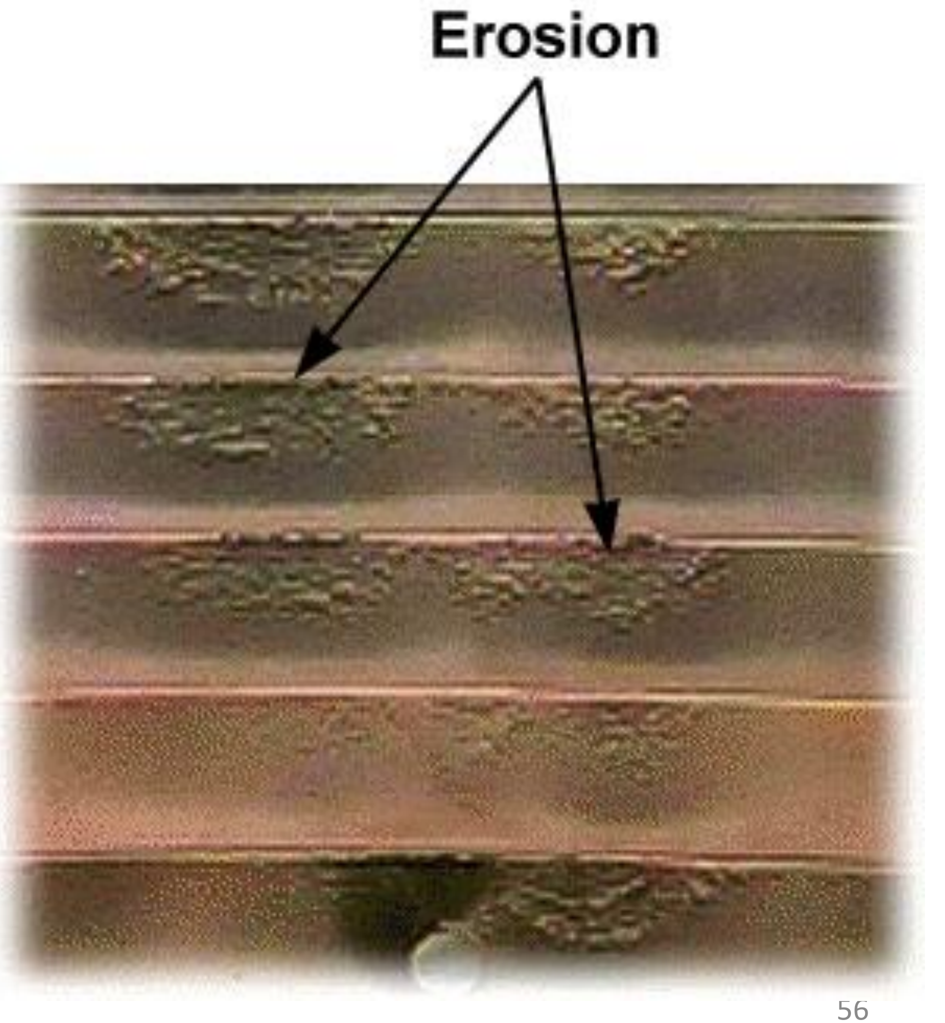
A crack is a thin split in the material. the length and direction of a crack is very important because it can determine the internal to the next inspection and if the engine must be removed and repaired



TYPES OF DAMAGE – COMBUSTION CHAMBER

j) EROSION

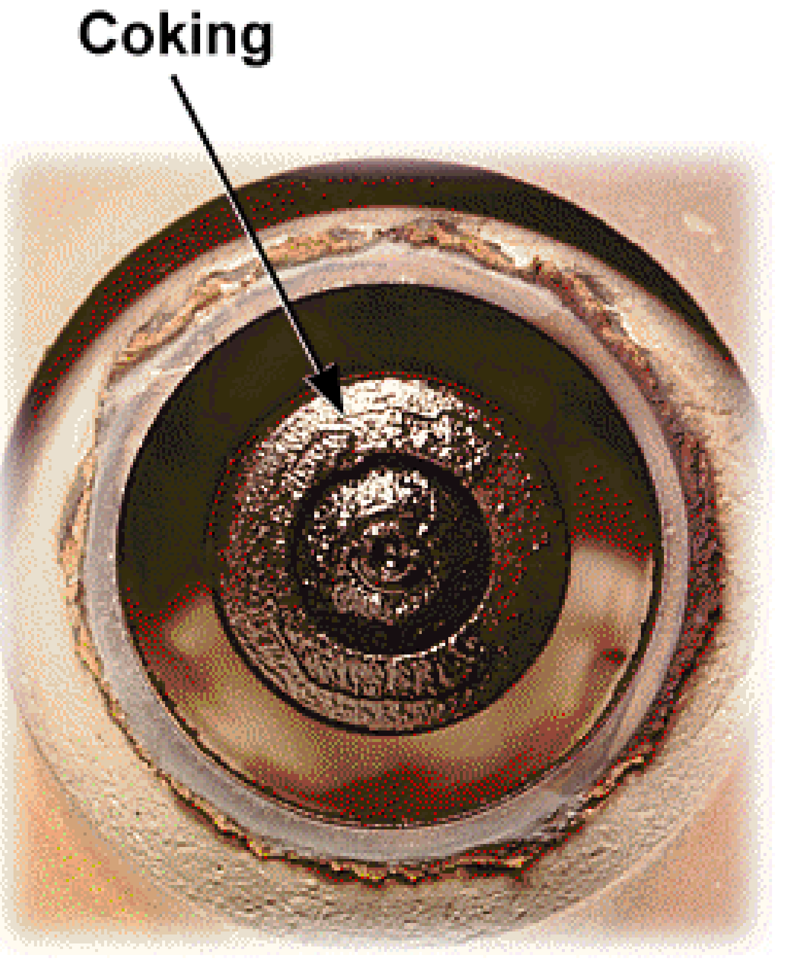
Erosion is the progressive wearing away of surface material



TYPES OF DAMAGE – COMBUSTION CHAMBER

k) COKING

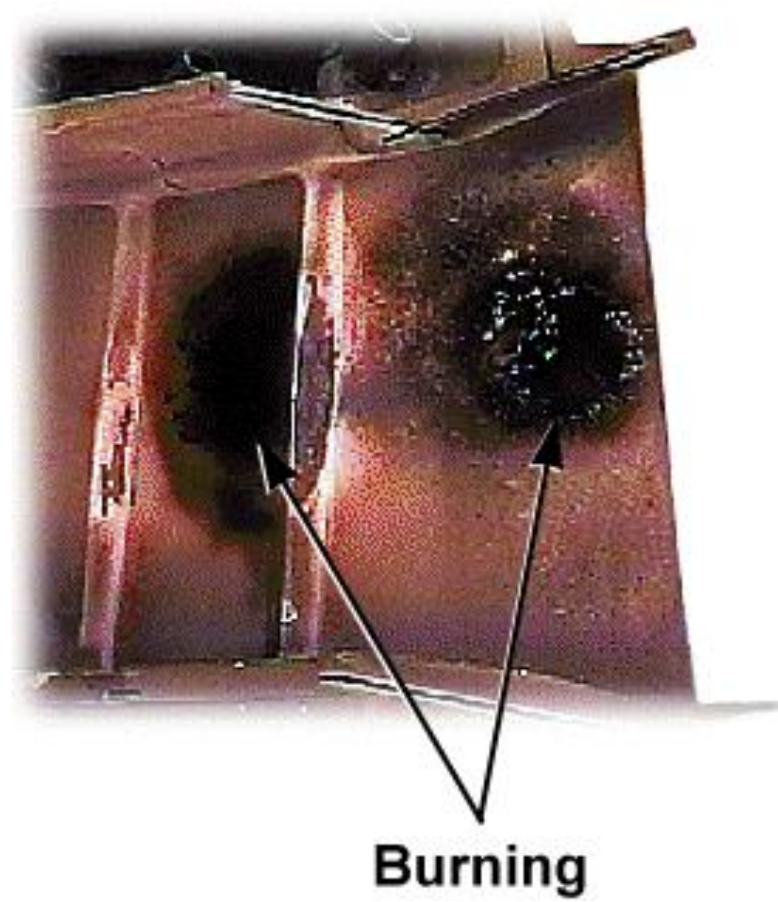
Coking is the deposit of fuel hydrocarborns on fuel nozzles, which clogs fuel passages or holes and thrust degrades the fuel spray pattern. Coking is different from the other types of combustion chamber damage because it occurs on the fuel nozzles (or injectors) , not on the combustion chamber surfaces.



TYPES OF DAMAGE – TURBINE

I) BURNING

Burning is a discoloration, deformation, and/or partial removal of material which is caused by the hot gases that flow over (impact against) its surface



TYPES OF DAMAGE – TURBINE

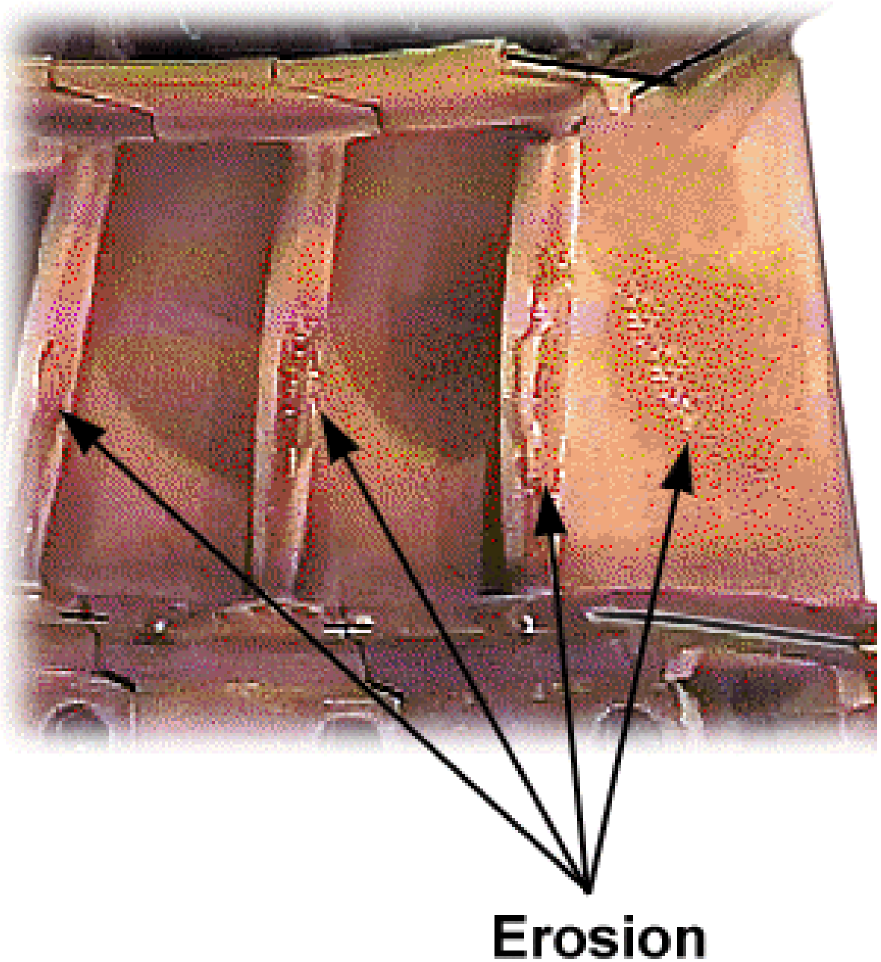
m) MISSING MATERIAL

Missing material is the loss of material due to burn-through or other causes. Typically, it is caused by a combination of damage such as a crack and burning and erosion

TYPES OF DAMAGE – TURBINE

n) EROSION

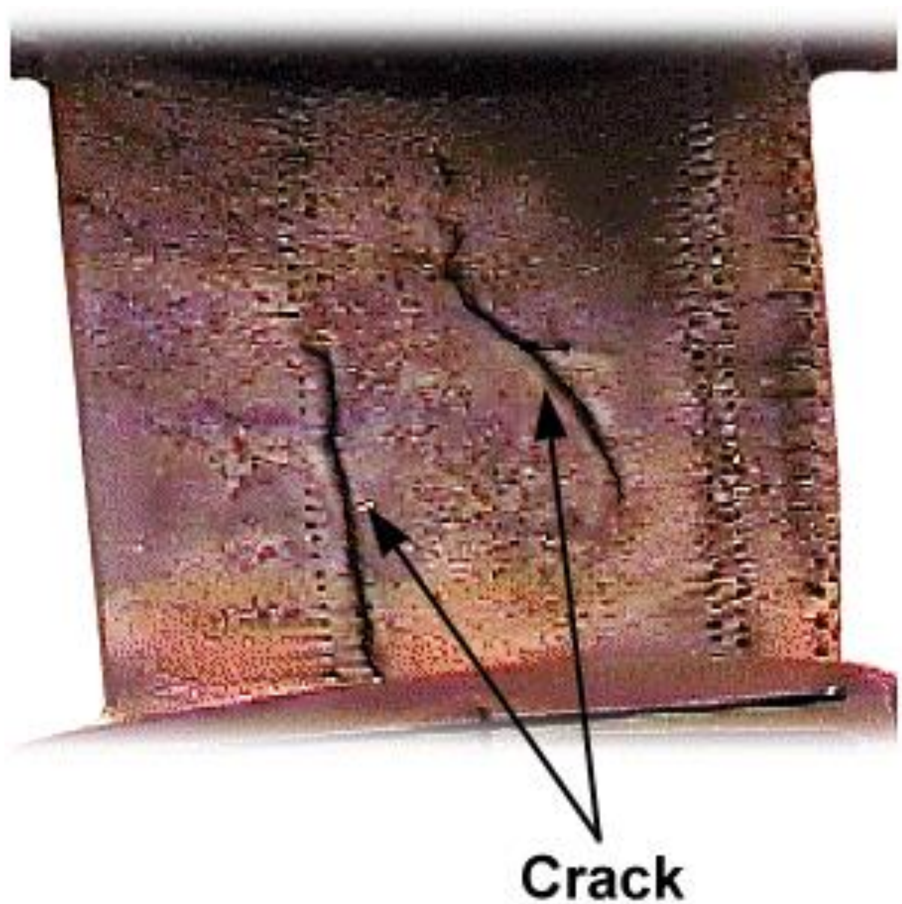
Erosion is the gradual removal of surface material by the nonchemical action of the hot gases



TYPES OF DAMAGE – TURBINE

o) CRACK

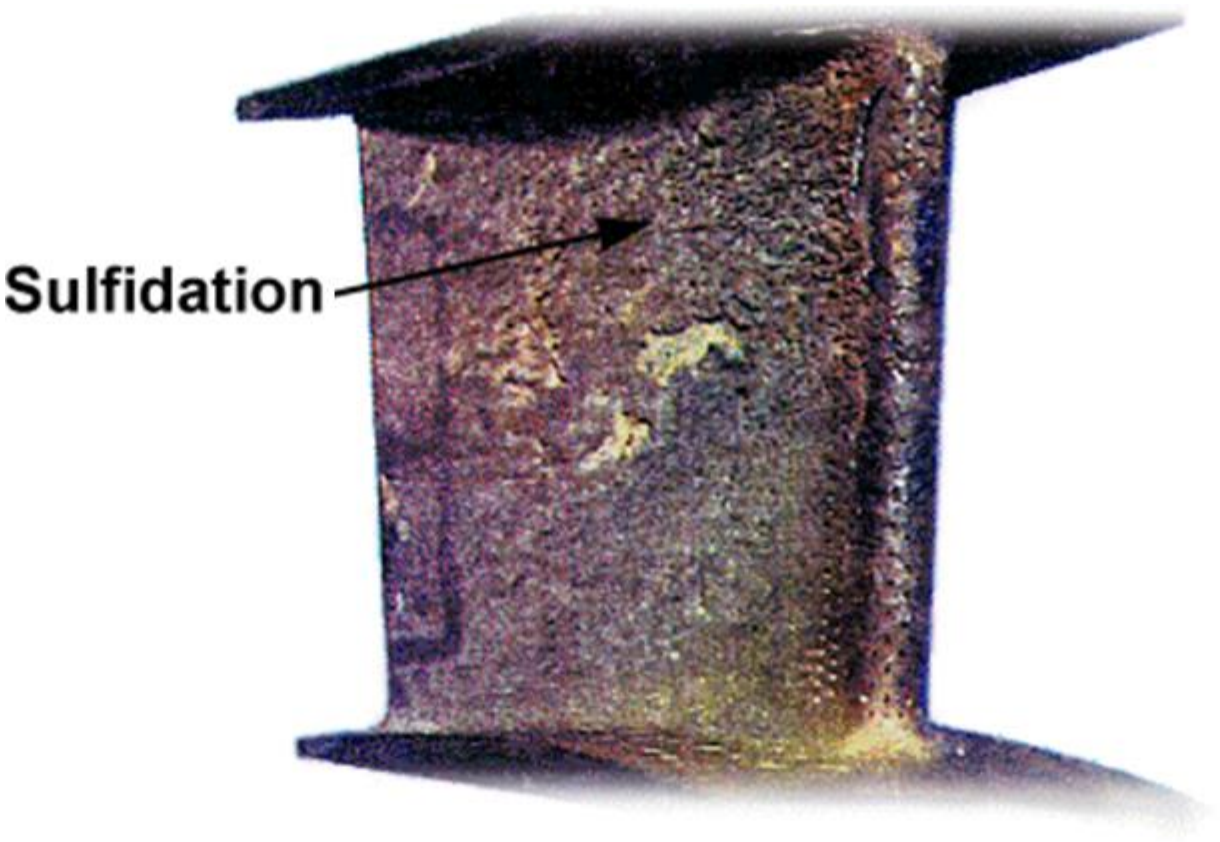
A crack is a narrow surface opening where the material has sepated. Cracks can be caused by metal fatigue that results from structural stresses, very high temperatures, erosion, corrosion , and combinations of these.



TYPES OF DAMAGE – TURBINE

p) SULFIDATION

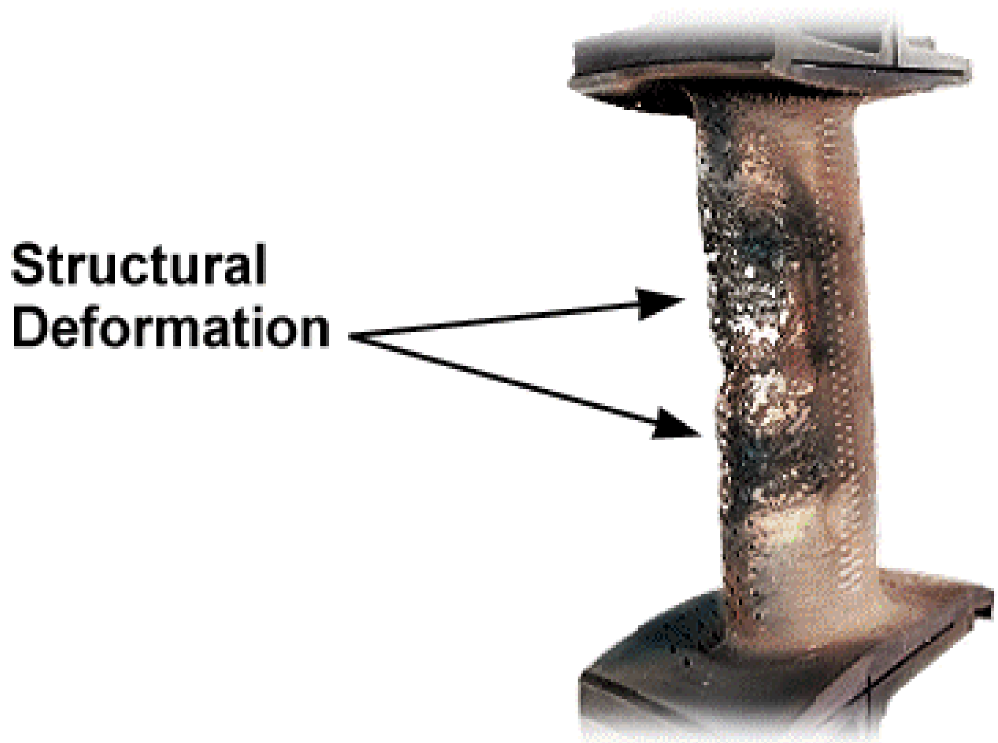
Sulfidation(hot corrosion) is an accelerated oxidation process caused by the deposit of alkalai metal sulfates on airfoil surfaces.



TYPES OF DAMAGE – TURBINE

q) STRUCTURAL DEFORMATION

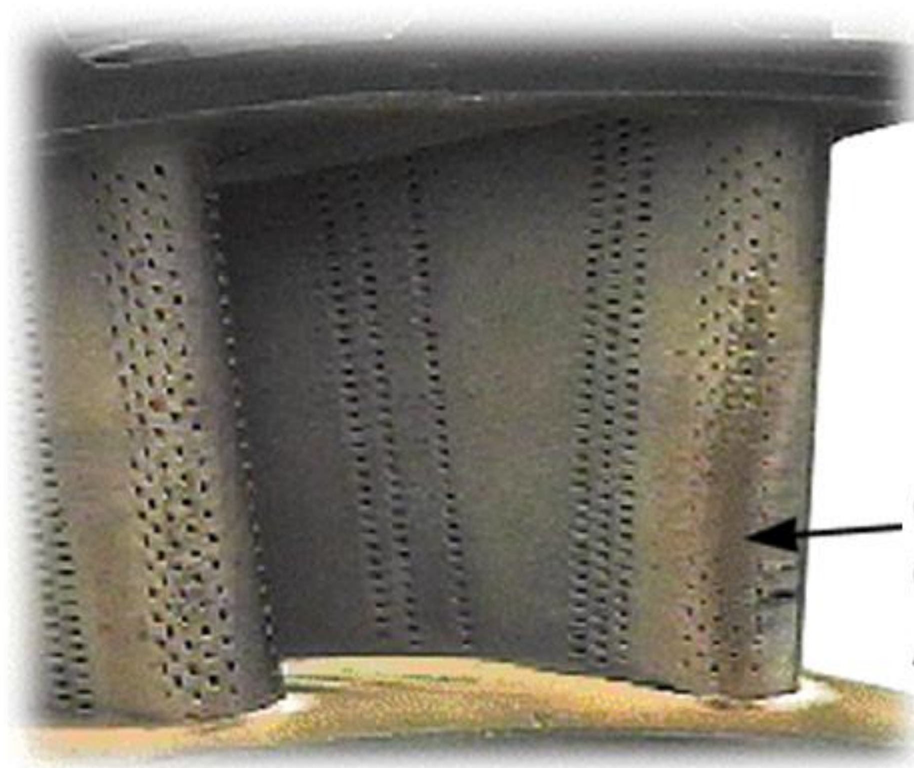
Structural deformation occurs if stress (caused by physical forces) and weakened material cause the vanes to bow(bend). This can cause a distortion of the gas flow and reduce engine performance



TYPES OF DAMAGE – TURBINE

r) CLOGGED COOLING AIR HOLES

In the high pressure turbine, some of the stages may have vanes with cooling air holes. If those holes become clogged, the amount of cooling is reduced. Then the vane can experience excessively high temperatures wich may cause further damage



Clogged Cooling Air Holes

THE END