به نام خدا

مبانی آزمون های غیرمخرب

تقسیم بندی عیوب

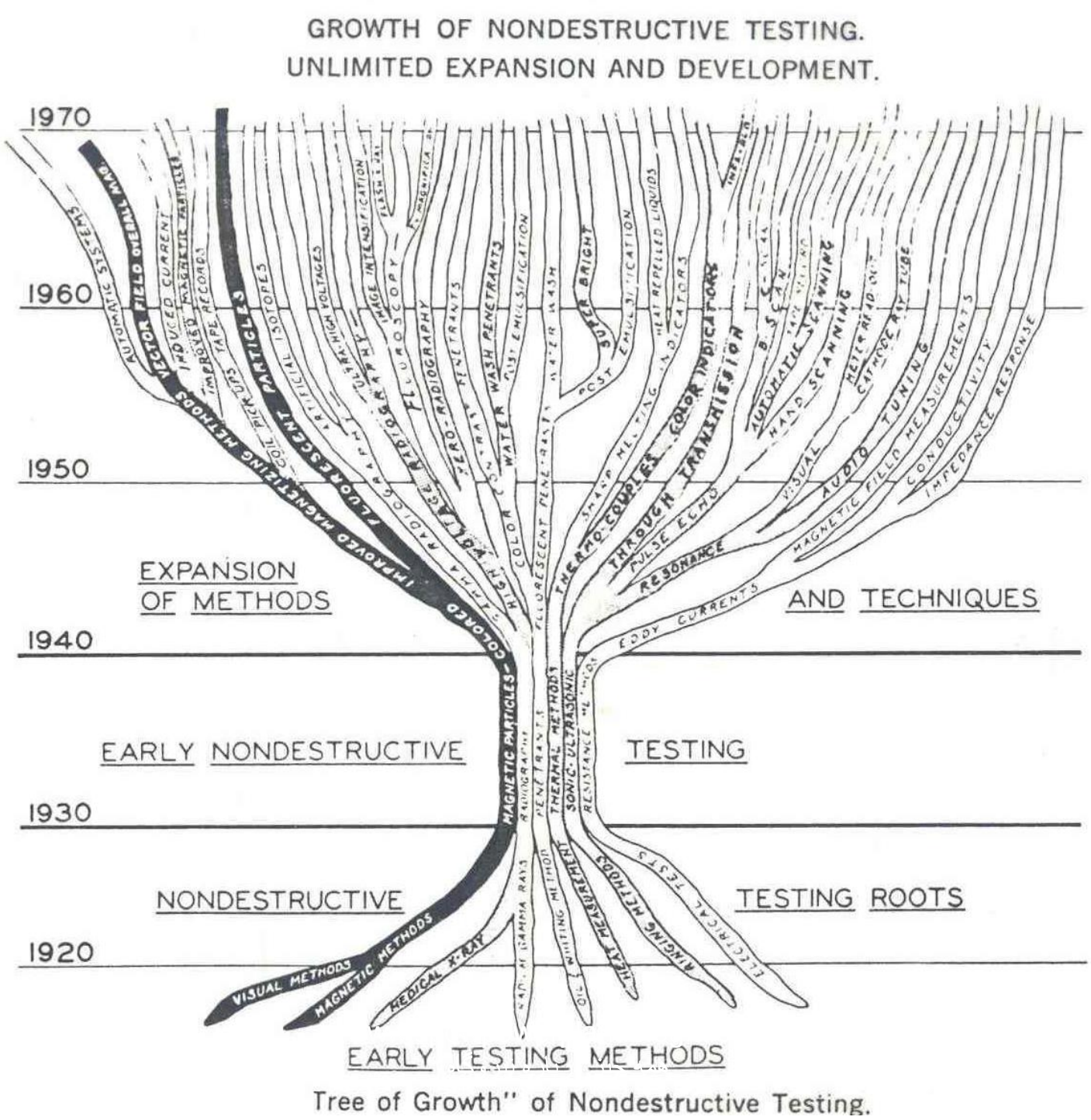
عیوب وناهماهنگیها نسبت به مراحل پدیدآمدن آنها به سه گروه عمده تقسیم میشود :

۱ـ عیوب درمرحله تولید

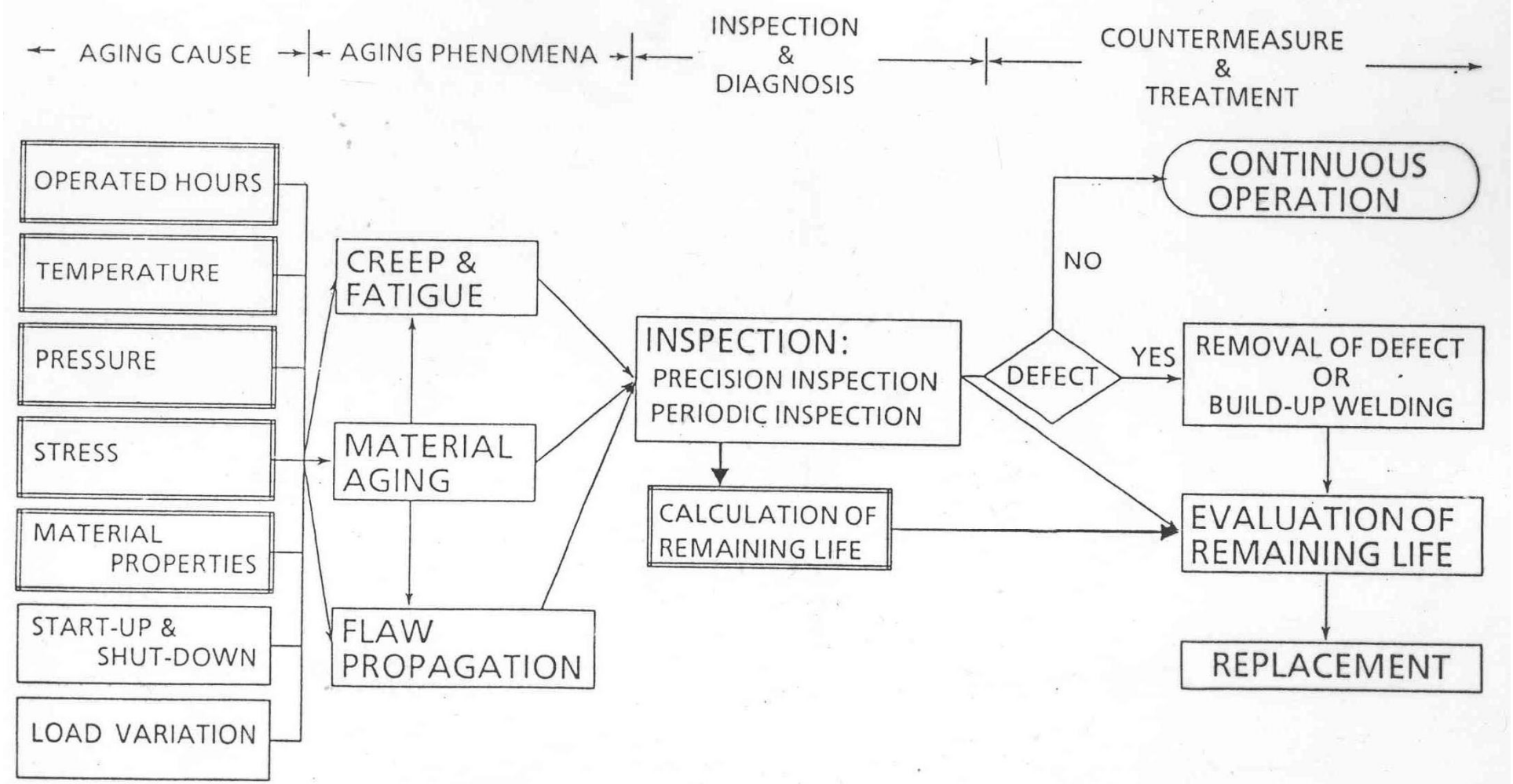
۲ـ عیوب درمرحله ساخت ومراحل تکمیلی آن

۳ـ عیوب درمرحله بهره برداری

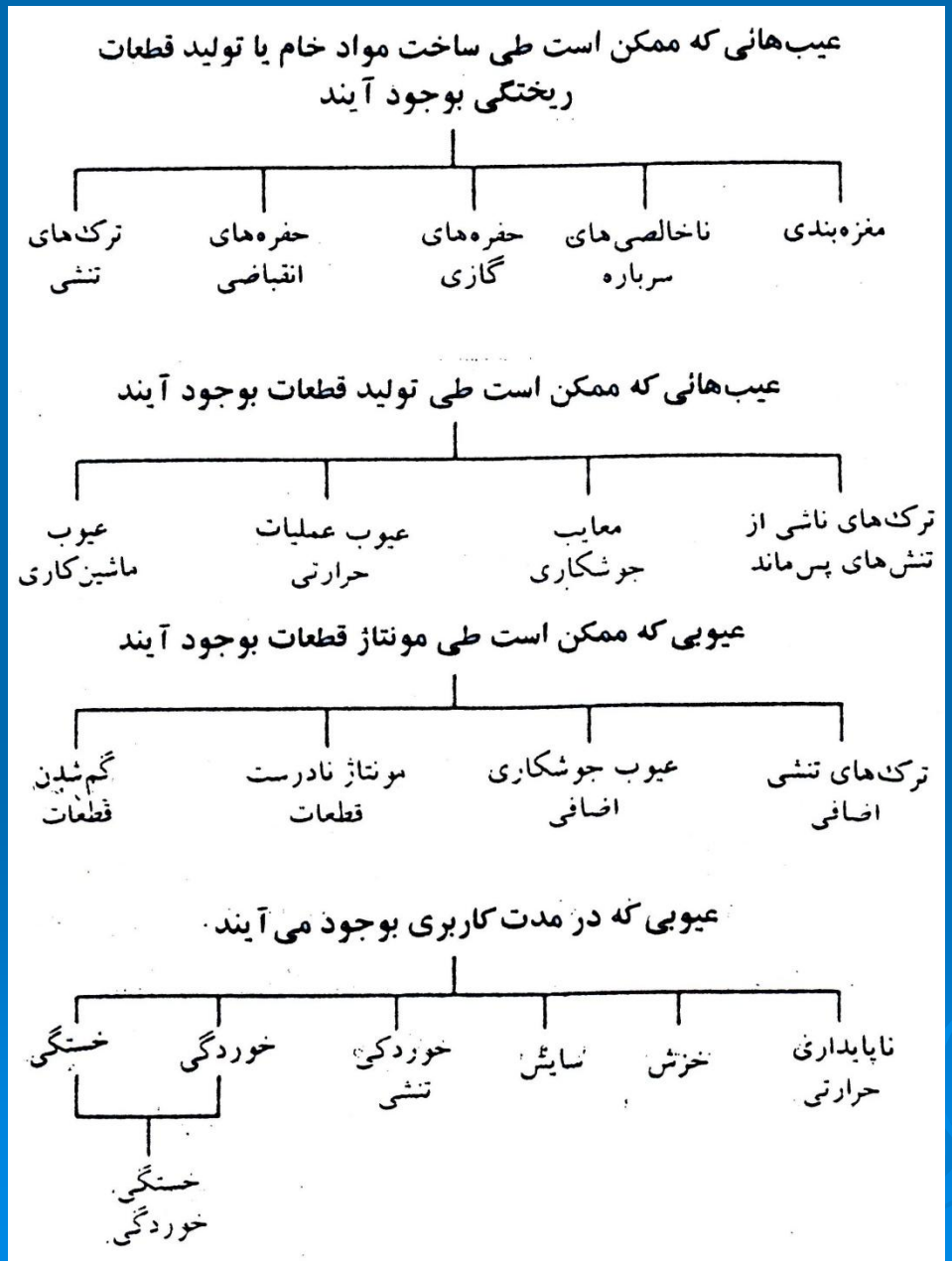
باتوجه به اهمیت بهره برداری بخصوص درنیروگاههای کشور ذیلا" بطورخلاصه به چگونگی بوجودآمدن این عیوب و راههای شناسائی آن می پردازیم

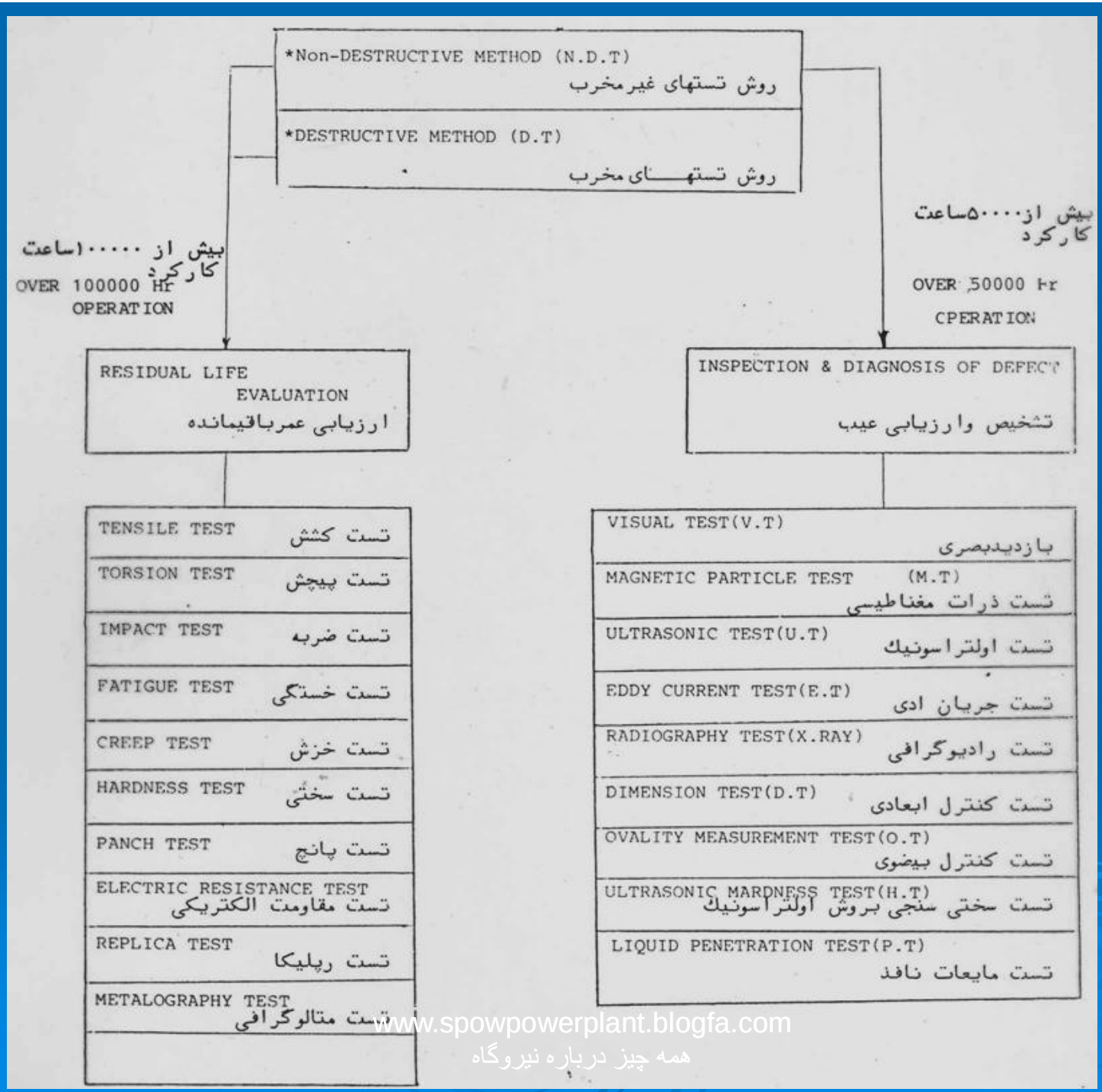


Tree of Growth" of Nondestructive Testing.


AGING CAUSE
AGING PHENOMENA
INSPECTION & DIAGNOSIS
COUNTERMEASURE & TREATMENT
OPERATED HOURS
TEMPERATURE
PRESSURE
STRESS
MATERIAL PROPERTIES
START-UP & SHUT-DOWN
LOAD VARIATION
CREEP & FATIGUE
MATERIAL AGING
FLAW PROPAGATION
INSPECTION:
PRECISION INSPECTION
PERIODIC INSPECTION
CALCULATION OF REMAINING LIFE
DEFECT
NO
YES
CONTINUOUS OPERATION
REMOVAL OF DEFECT OR BUILD-UP WELDING
EVALUATION OF REMAINING LIFE
REPLACEMENT

منشأ بعضی عیب‌هایی که در مواد و قطعات یافت می‌شوند





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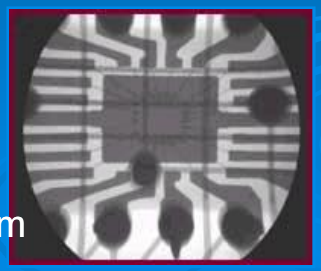
NDT METHODS

- Penetrant Inspection
- Magnetic Particle Inspection
- Eddy Current Inspection
- Ultrasonic Inspection
- Radiographic Inspection



آزمون‌های متداول غیرمخرب

سیستم (روش)	چگونگی عیب‌یابی	موارد استعمال
مایع نافذ	آشکارسازی عیب‌هایی که سطح قطعه را ترک می‌دهند.	برای تمام فلزات، اغلب پلاستیک‌ها، شیشه و سرامیک‌های لعاب‌دار می‌توان به کار برد.
ذرات مغناطیسی	آشکارسازی عیب‌هایی که سطح و زیرسطح نزدیک به آن را ترک می‌دهند.	فقط برای مواد فرومغناطیسی قابل استفاده است (اغلب فولادها و چدن‌ها)
روش‌های الکتریکی (جریان‌های گردابی)	آشکارسازی عیب‌های سطحی بعضی از عیب‌های زیرسطحی، همچنین برای اندازه‌گیری ضخامت پوشش نارسانا، مانند رنگ روی فلز	برای هر نوع فلزی می‌تواند قابل استفاده باشد.
آزمون فراصوتی	آشکارسازی عیب‌های داخلی، همچنین عیب‌های سطحی	برای اغلب مواد می‌تواند قابل استفاده باشد.
رادیوگرافی	آشکارسازی عیب‌های داخلی، عیب‌های سطحی و نادرستی مونتاژ قطعات	برای اغلب مواد می‌تواند قابل استفاده باشد اما حداکثر ضخامت ماده محدودیت‌هایی دارد.

مراحل آزمون مایع نافذ

1- آماده‌سازی سطح قطعه یا تمیزکاری اولیه
2- اعمال مایع نافذ
3- تمیز کردن مایع اضافی
4- اعمال ماده ظهور
5- مشاهده و بازرسی
6- تمیزکاری نهایی

طبقه‌بندی مایعات نافذ

مایعات فاقد بر تقسیم‌بندی تحت به دو گروه مرئی و فلورسنت تقسیم می‌شوند. مایع نافذ مرئی که عموما قرمز رنگ هستند در زیر نور معمولی قابل رؤیت می‌باشد. اما مایع نافذ فلورسنت فقط در زیر نور سیاه مشخص می‌شود. همچنین مایعات نافذ دوگانه هم وجود دارد. یعنی هم زیر نور معمولی و هم زیر نور سیاه قابل رؤیت می‌باشند.

هر یک از گروه نامبرده خود به سه گروه زیر تقسیم می‌شوند.

1- مایع نافذ قابل شستشو در آب water washable penetrant
2- مایع فوق محلول Post emulsify
3- سیستم تمیزکردن با حلال Solvent removable

زمان لازم برای نفوذ مایع در حالتهای مختلف برای چند فلز

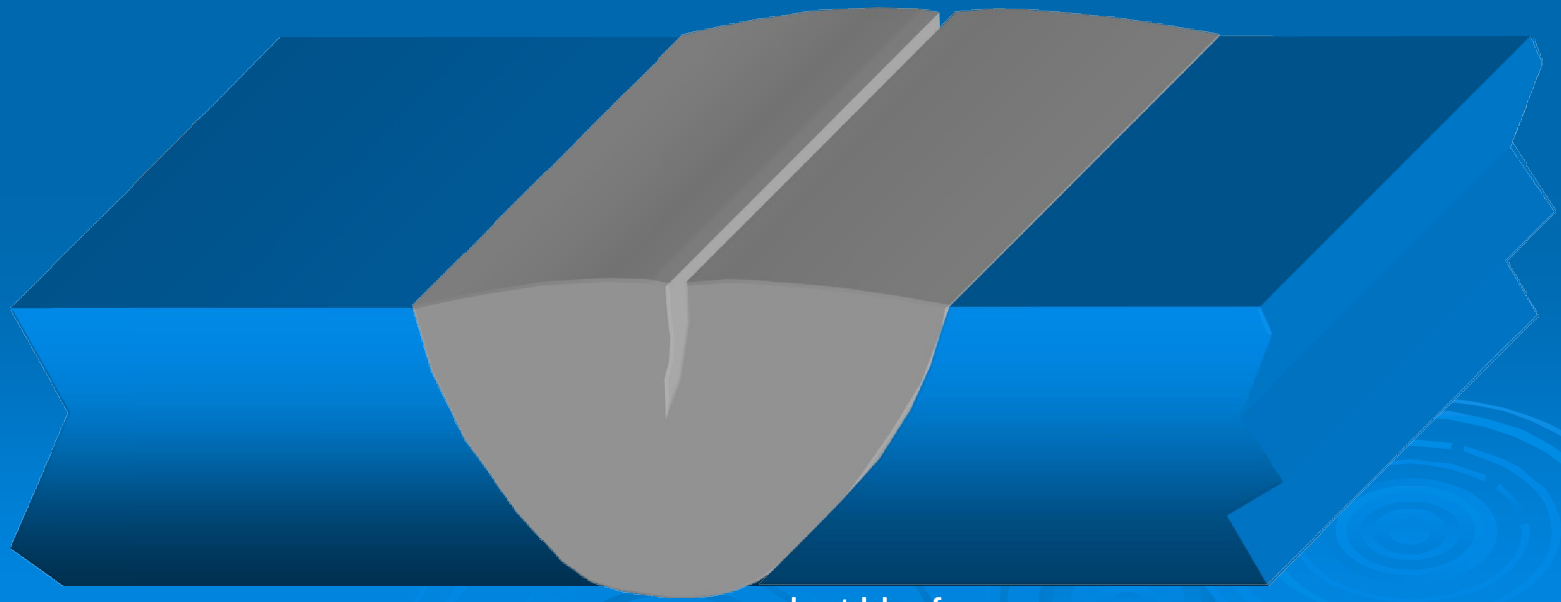
Material	Form	Type of Discontinuity	Water Washable Penetration Time	Post Emulsified Penetration Time	Solvent Removed Penetration Time
Aluminum	Castings	Porosity cold shuts	5 to 15 min 5 to 15	5 Min .. 5 ..	3 Min 3
	Extrusions &forgings	Laps	NR …	10	7
	Welds	Lack of fusion porosity	30 30	5 5	3 3
	All	Cracks fatigue cracks	30 NR …	10 30	5 5
Magnesium	Castings	Porosity cold shuts	15 15	5 .. 5 ..	3 3
	Extrusions &forgings	Laps	NR …	10	7
	Welds	Lack of fusion porosity	30 30	10 10	5 5
	All	Cracks Fatigue cracks	30 NR …	10 30	5 7

Dye Penetrant Inspection

Dye Penetrant Inspection

Dye Penetrant Inspection

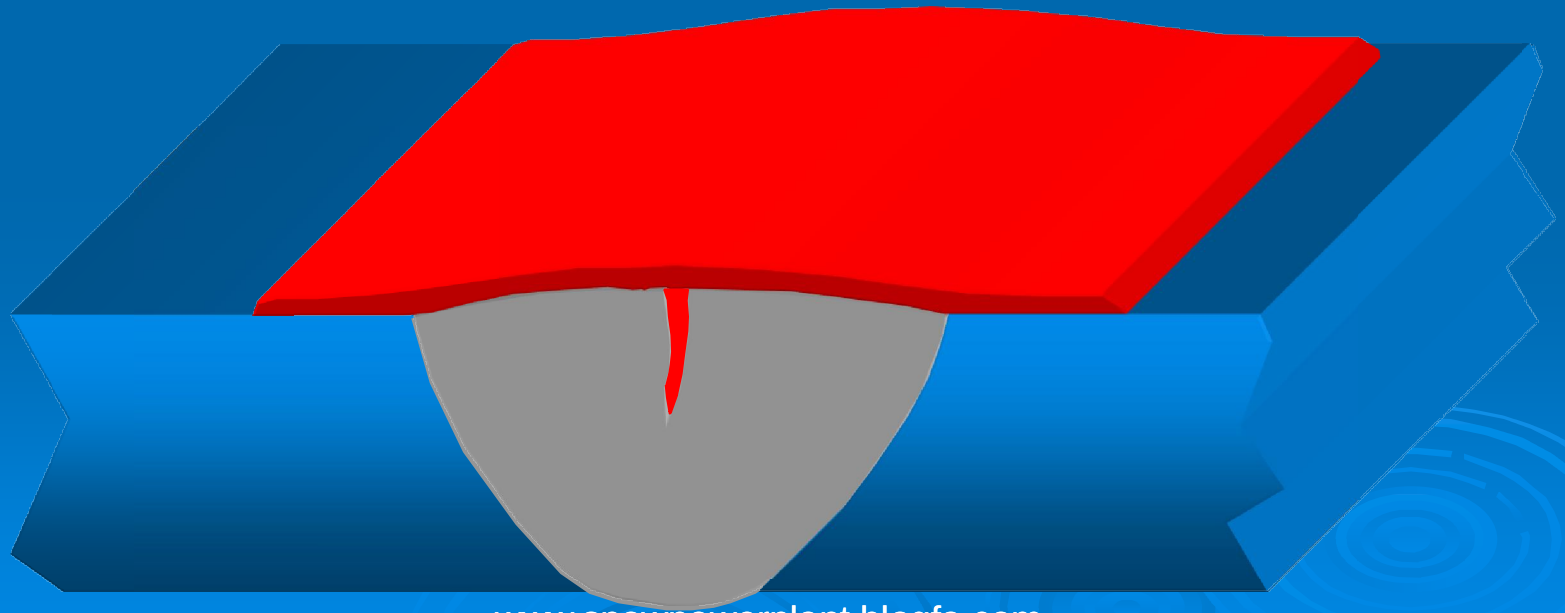
Step 1. Pre-Cleaning
Cleaning preparation is very important on this method.
Usually solvent removal is been used



Dye Penetrant Inspection

Step 2. Apply penetrant

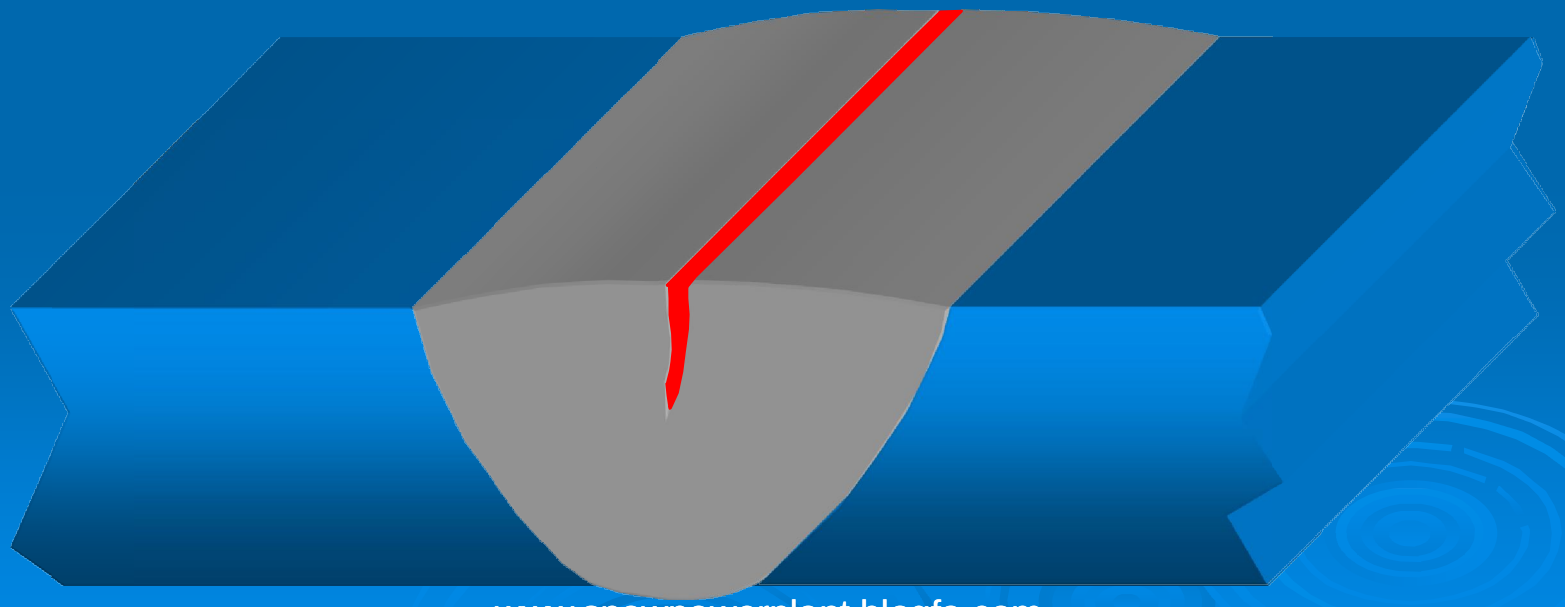
After the application of the penetrant the penetrant is normally left on the components surface for approximately 15 minutes (dwell time). The penetrant enters any defects that may be present by capillary action



Dye Penetrant Inspection

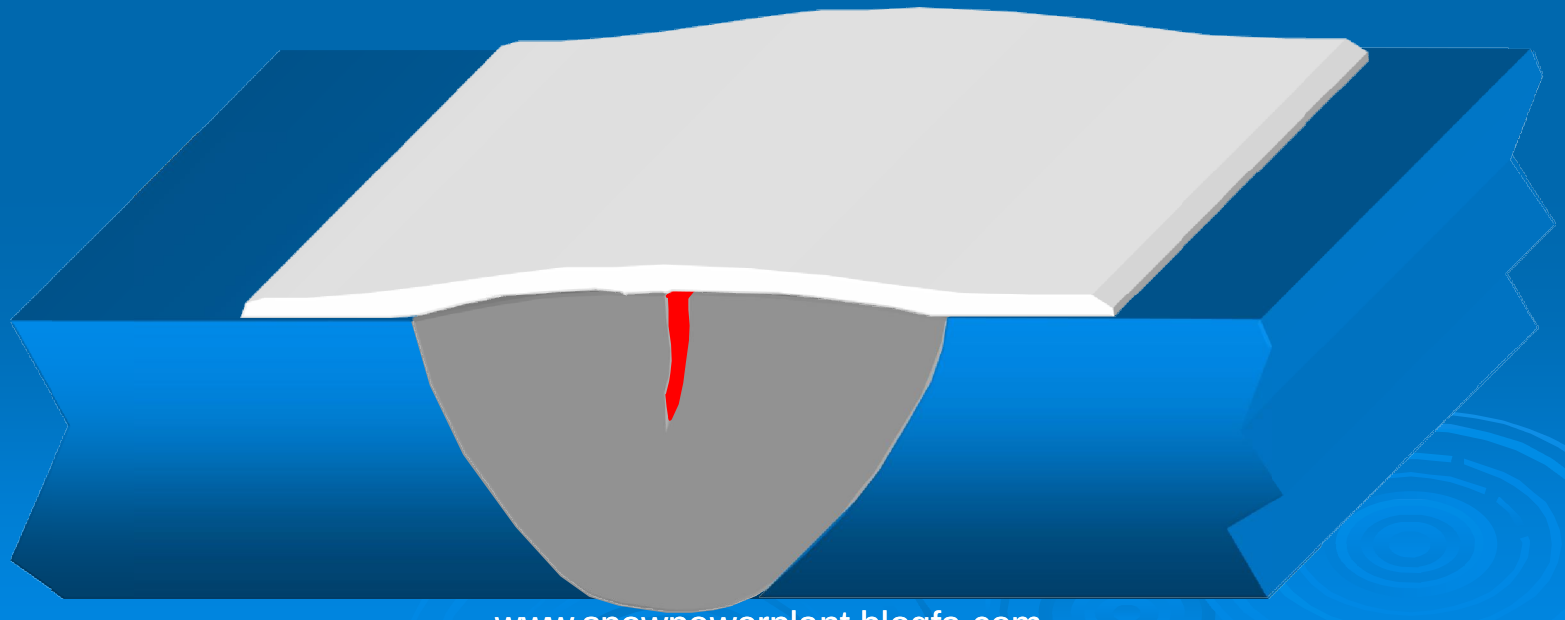
Step 3. Clean off penetrant

After sufficient penetration time (dwell time) has been given,excess removal penetrant stage take place. A damped lint free tissue with solvent is used to clean the excess penetrant.



Dye Penetrant Inspection

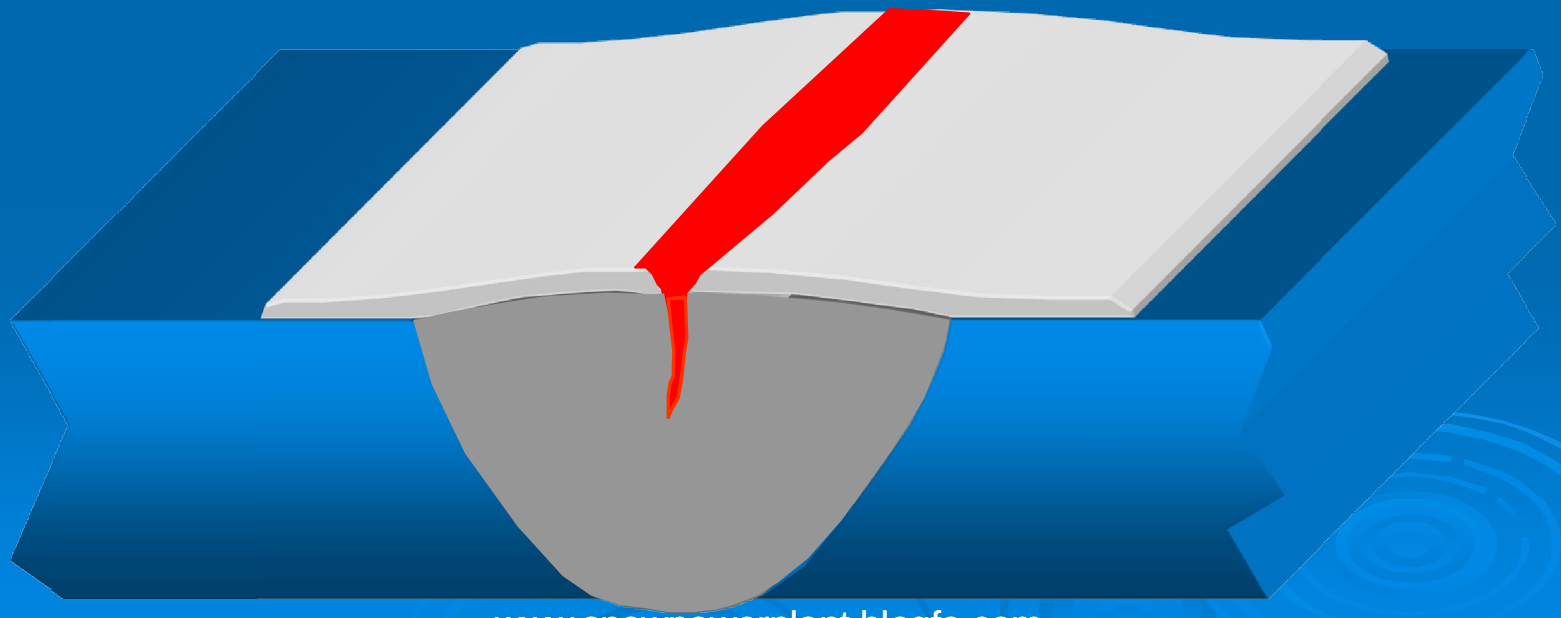
Step 3. Apply developer
After the excess penetrant is been removed, a thin layer of developer is applied.A penetrant drawn out by reversed capillary action.



Dye Penetrant Inspection

Step 4. Inspection / development time

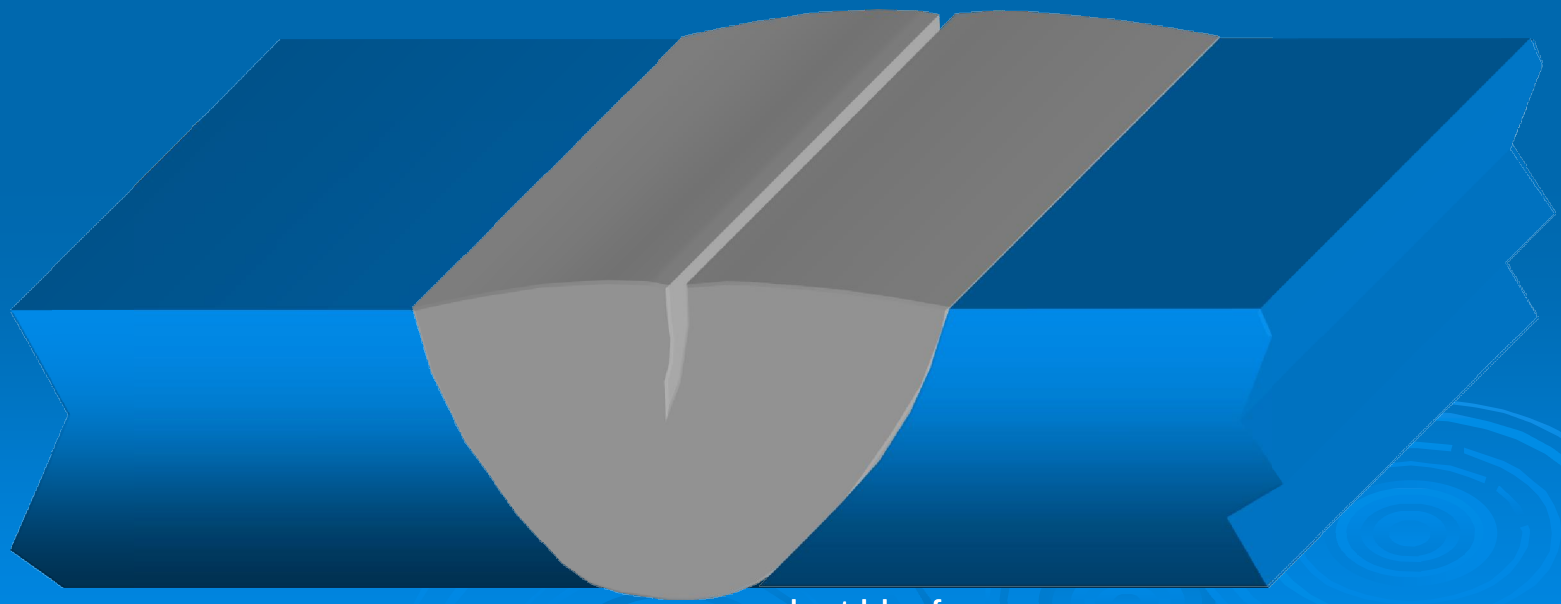
Inspection should take place immediately after the developer has been applied .Any defects present will show as a bleed out during development time.



Dye Penetrant Inspection

Step 5. Post-Cleaning

After the inspection has been performed post cleaning is required to prevent corrosion.



Dye Penetrant Inspection

Fluorescent Penetrant

Bleed out viewed under a UV-A light source

Bleed out viewed under white light

Colour contrast Penetrant

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Magnetic Particle Inspection

TWI

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Magnetic Particle Inspection

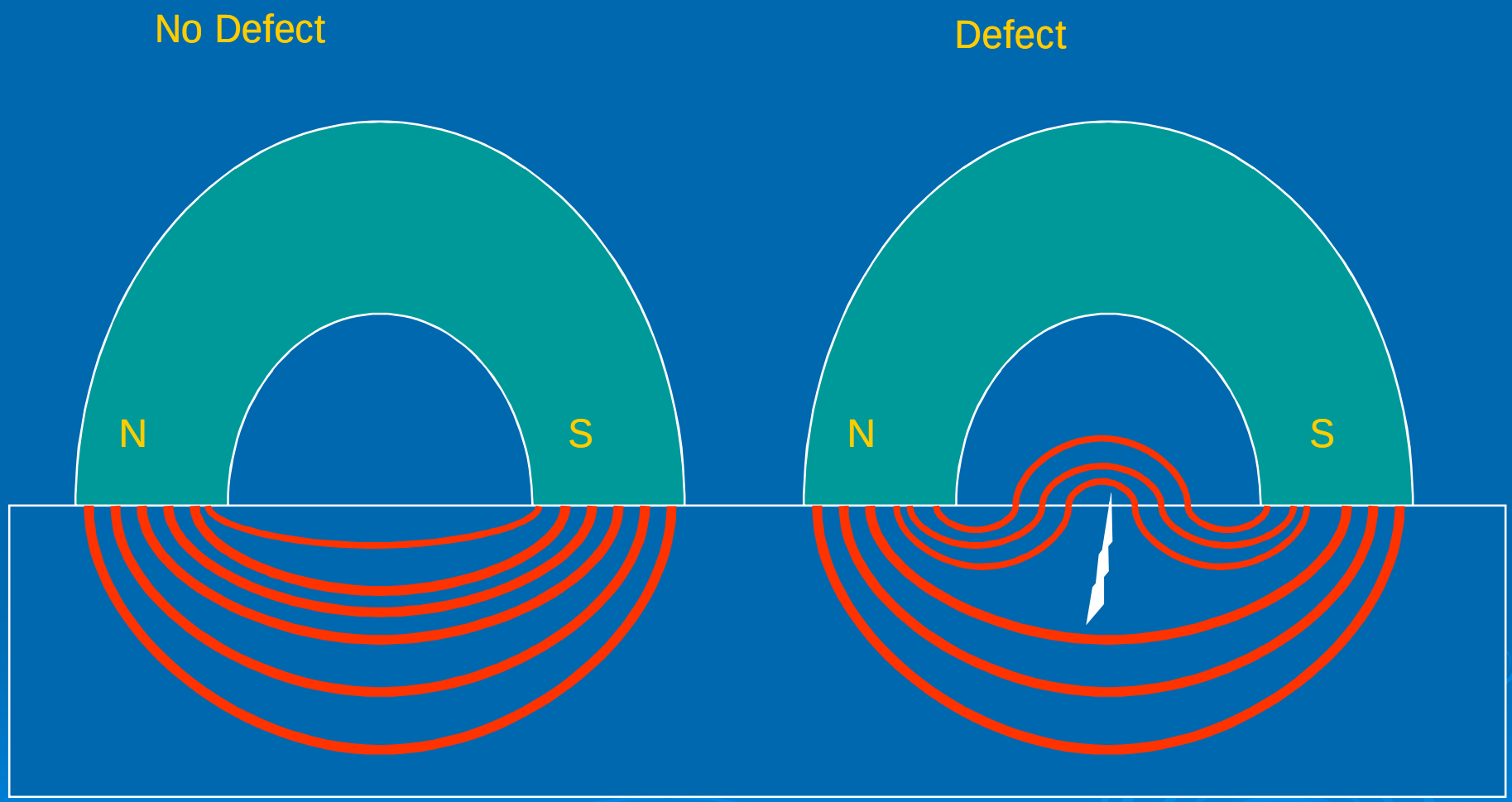
- Surface and slight sub-surface detection
- Relies on magnetization of component being tested
- Ferro-magnetic materials only can be tested
- A magnetic field is introduced into a specimen being tested
- Methods of applying a magnetic field, yolk, permanent magnet, prods and flexible cables.
- Fine particles of iron powder are applied to the test area
- Any defect which interrupts the magnetic field, will create a leakage field, which attracts the particles
- Any defect will show up as either a dark indication or in the case of fluorescent particles under UV-A light a green/yellow indication

Magnetic Particle Inspection

(MT or MPI)

- MT is a test method for the detection of surface and near surface defects in ferromagnetic materials.
- Magnetic field induced in component
- Defects disrupt the magnetic flux causing “flux leakage”.
- Flux leakage can be detected by applying ferromagnetic particles

Principle of MPI : Flux Leakage



Lines of flux follow the path of least resistance

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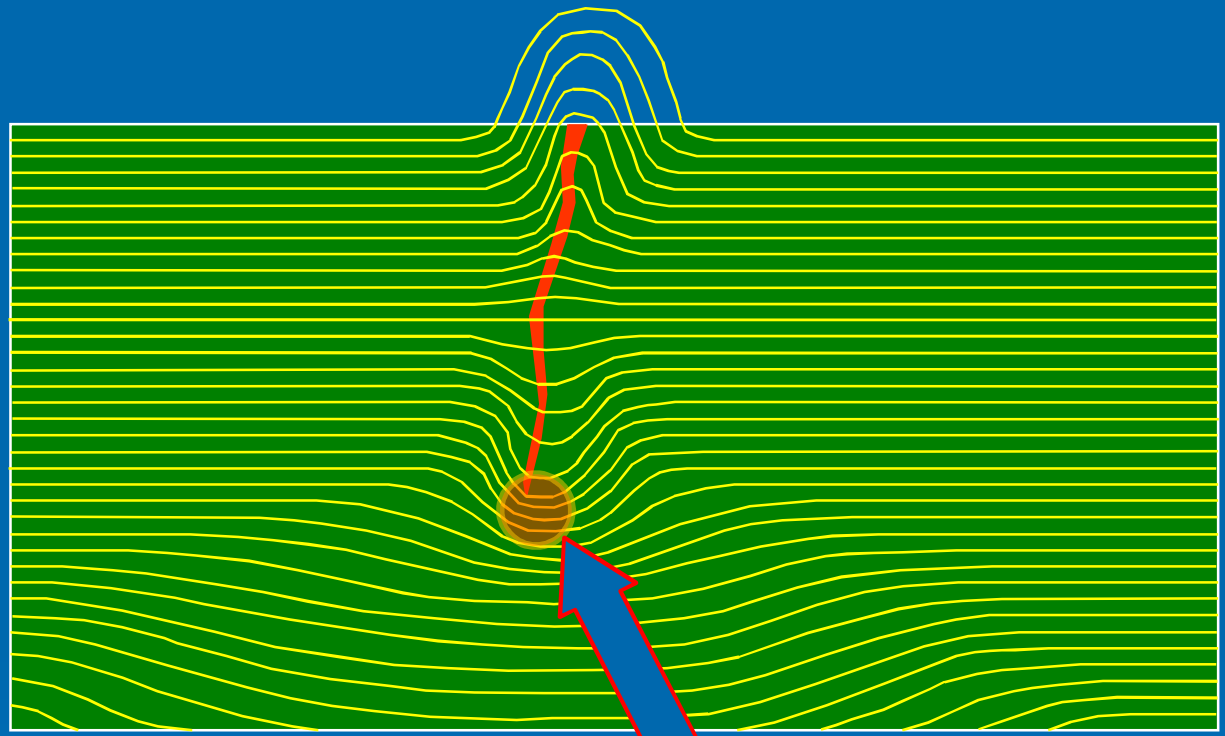
LEAKAGE FIELDS



MAGNETIC SATURATION

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Visibility of Flux Leakage

Depends on:

- Depth of defect
- Orientation of defect shape of defect
- Size of defect
- Permeability of material
- Applied Field Strength
- Contrast

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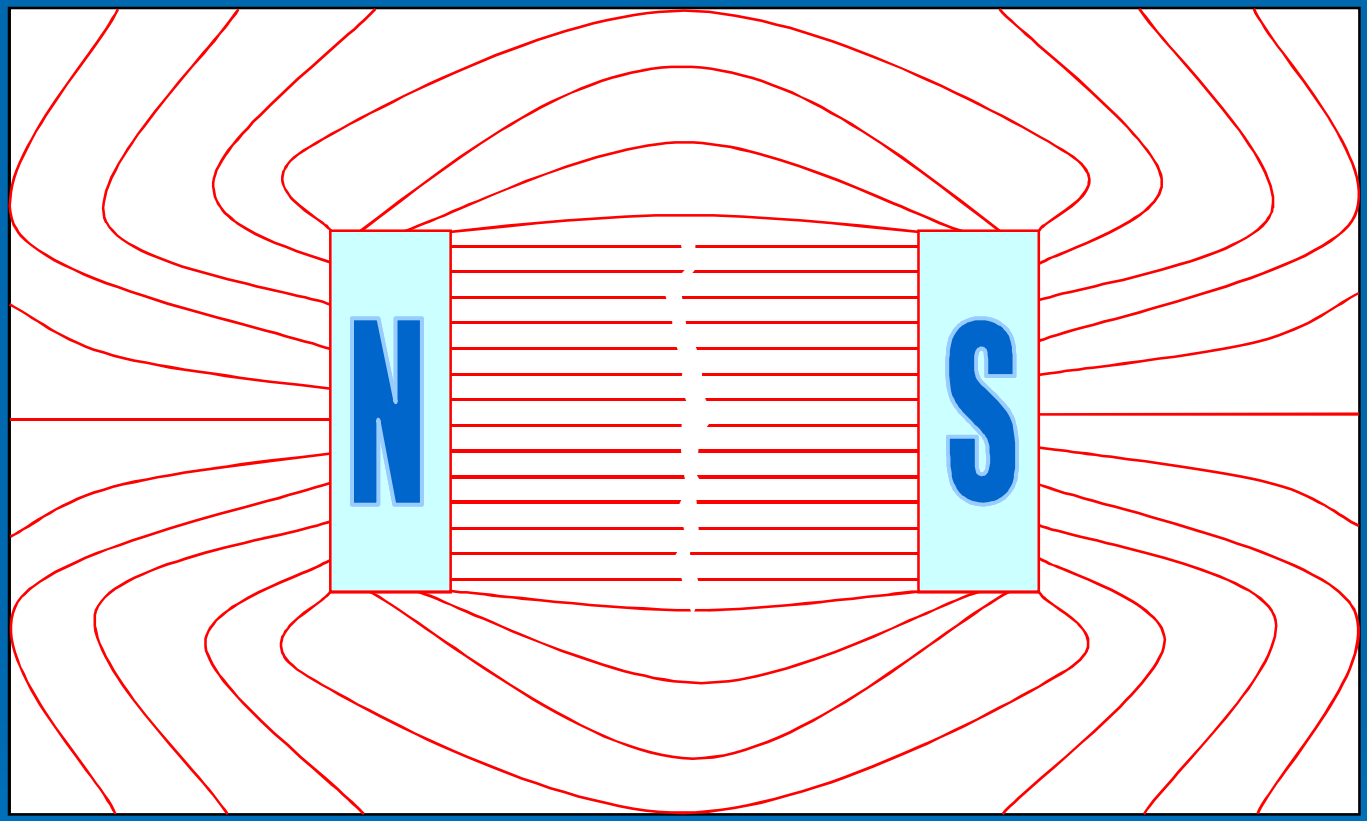
Defect Orientation



Defect at 90 degrees to flux : maximum indication

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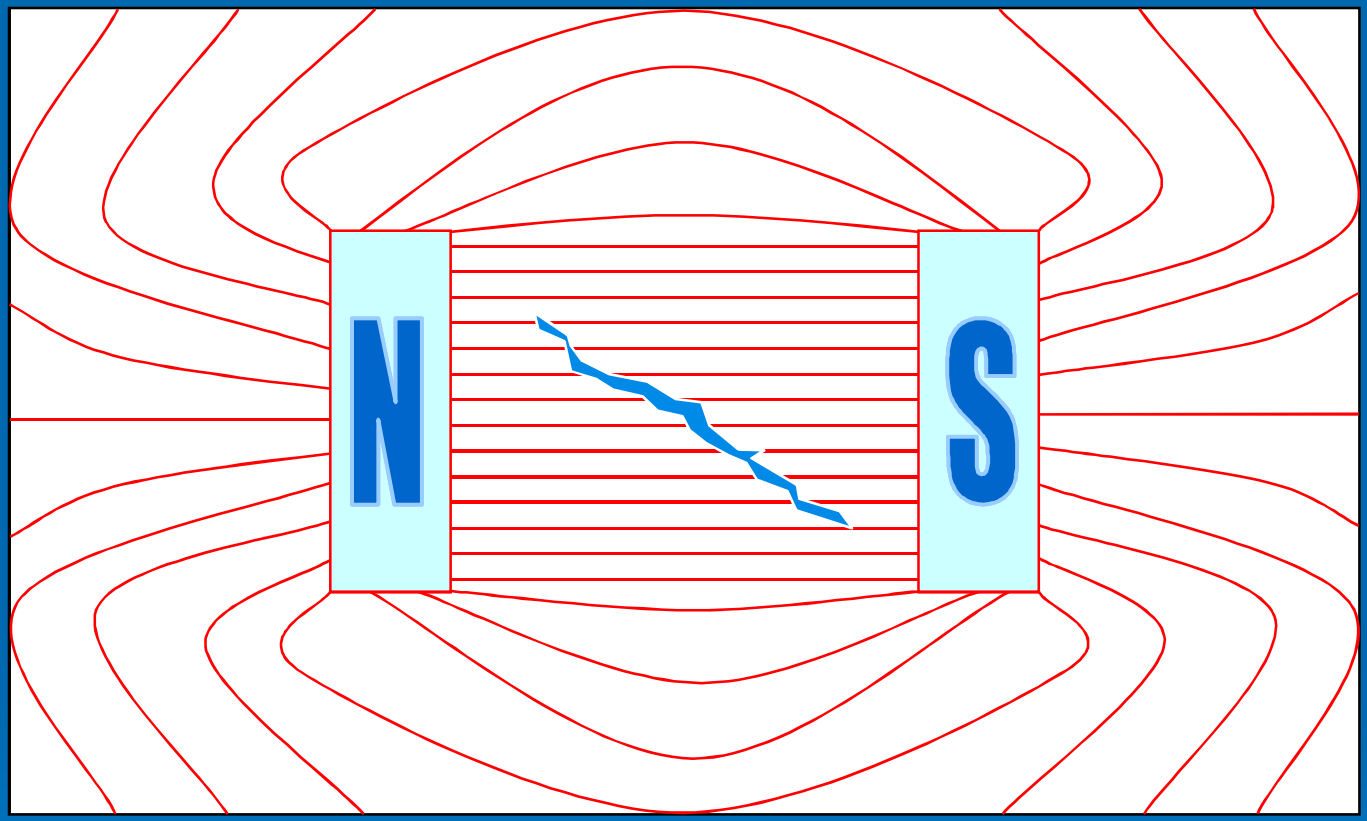
Defect Orientation



>30 Degrees to Flux: Acceptable indication

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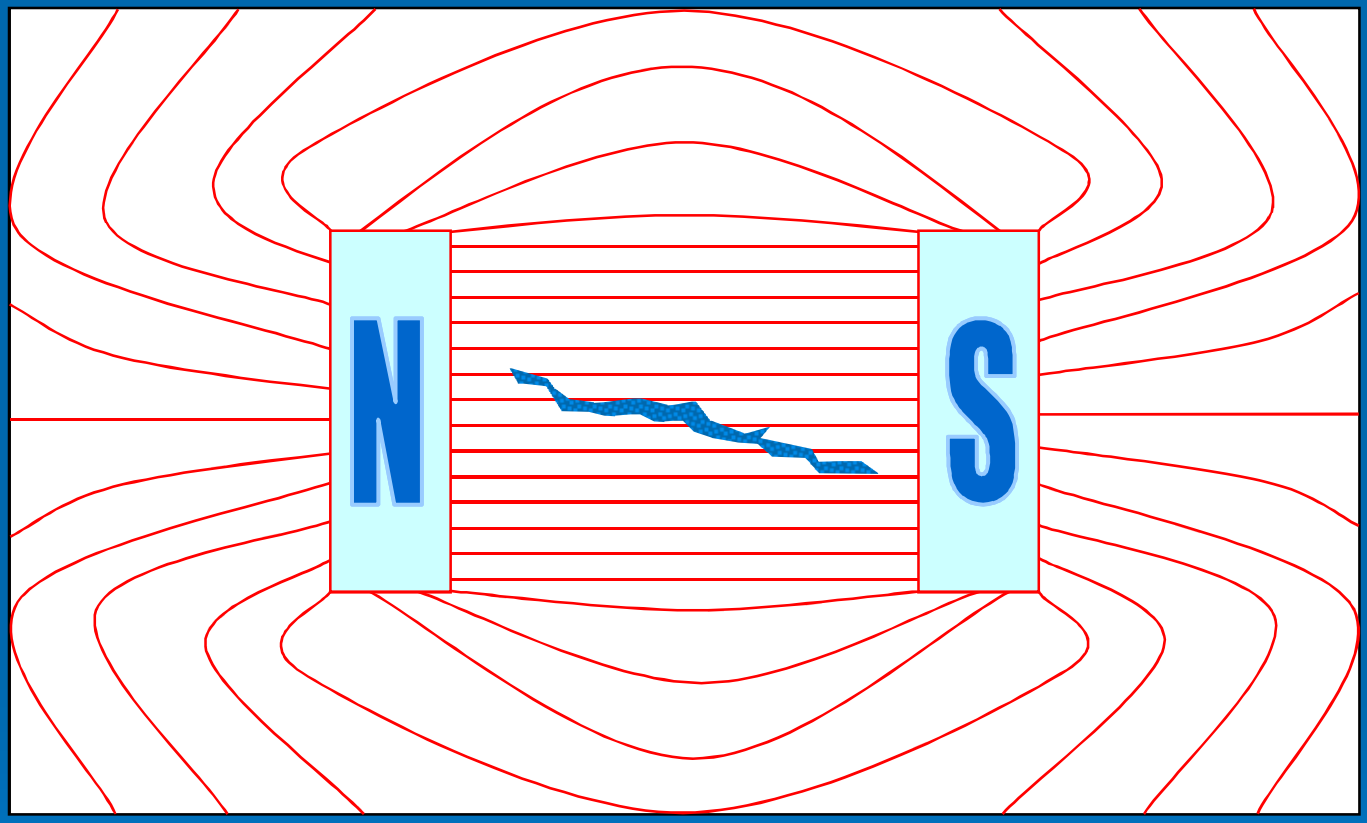
Defect Orientation



<30 Degrees to Flux : Weak indication

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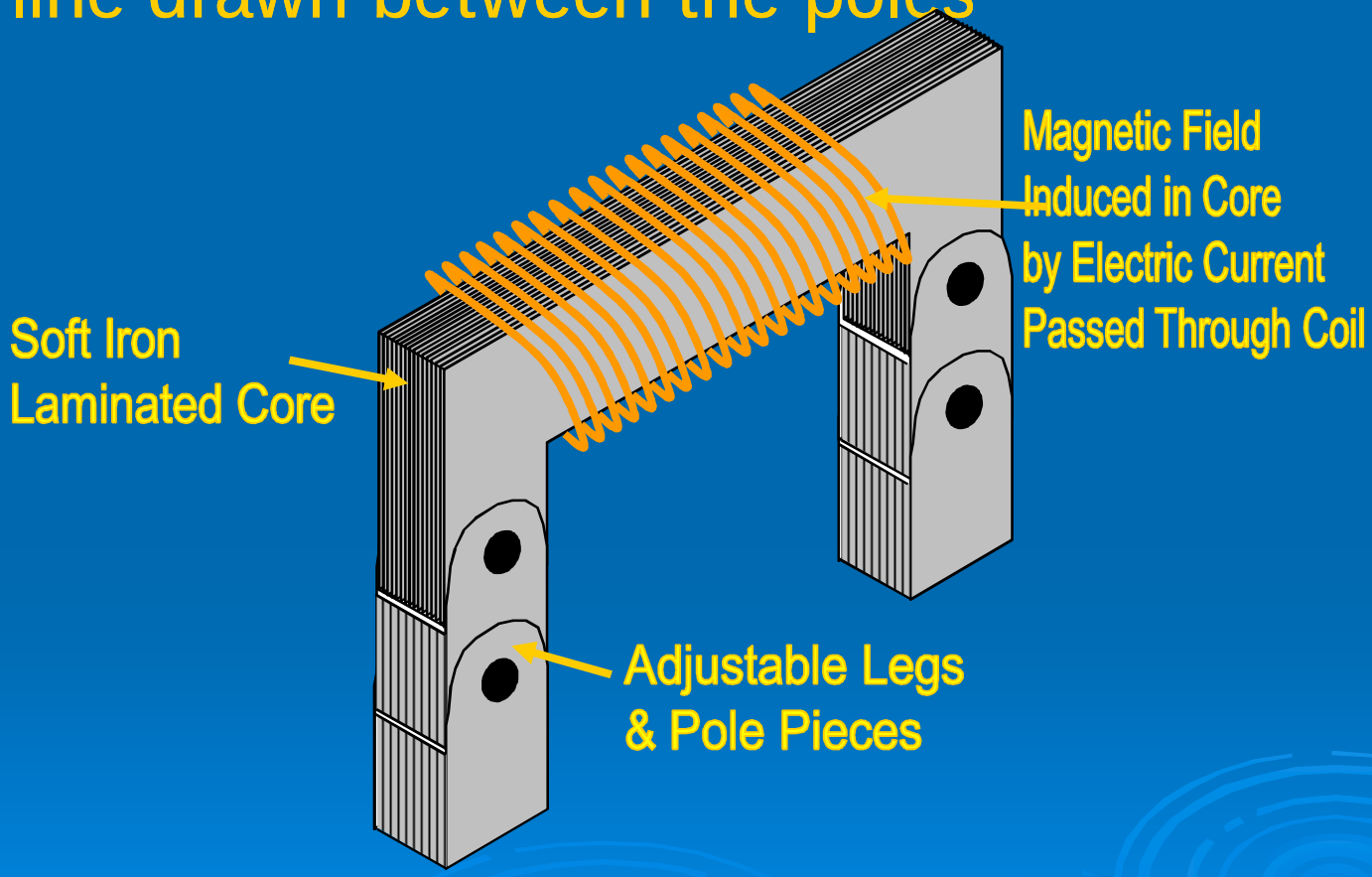
Equipment

Electromagnets

Maximum sensitivity for defects orientated at 90º to a line drawn between the poles



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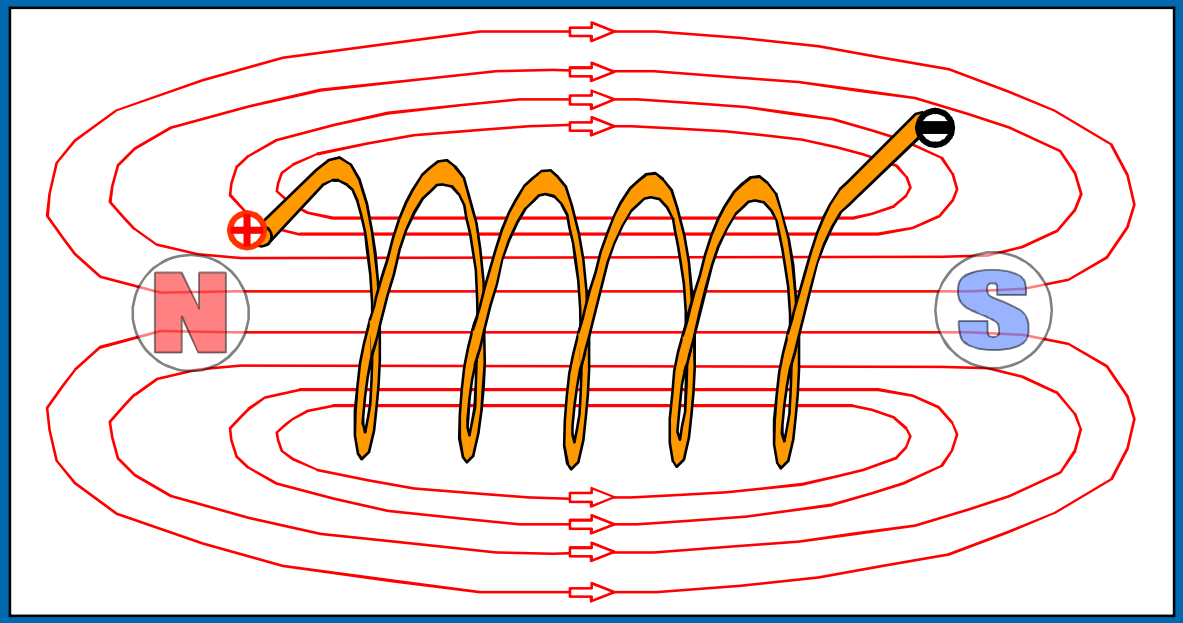
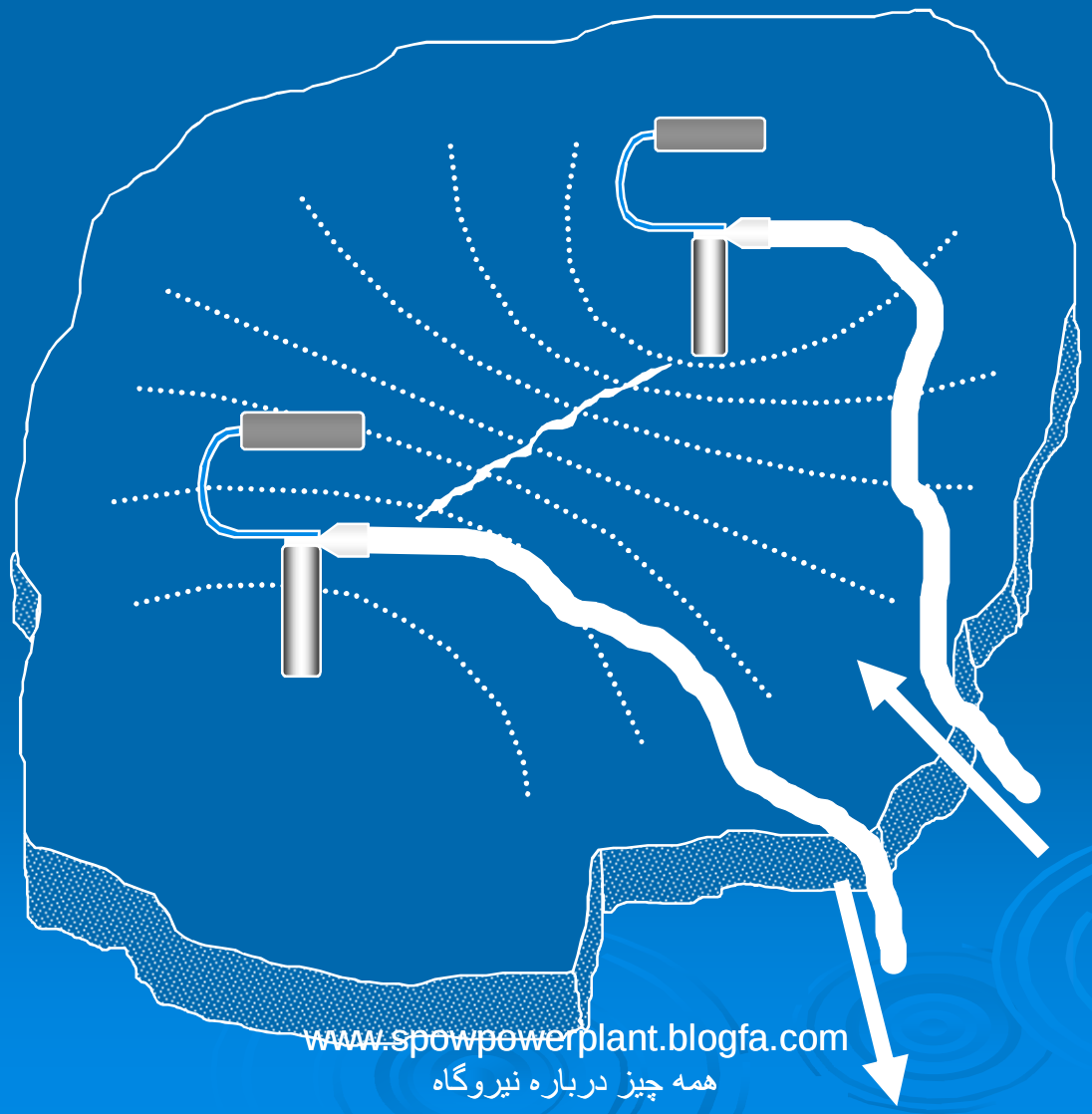
Coil Magnetisation



- Changes circular field into longitudinal
- Increases the strength of the field

PROD METHOD



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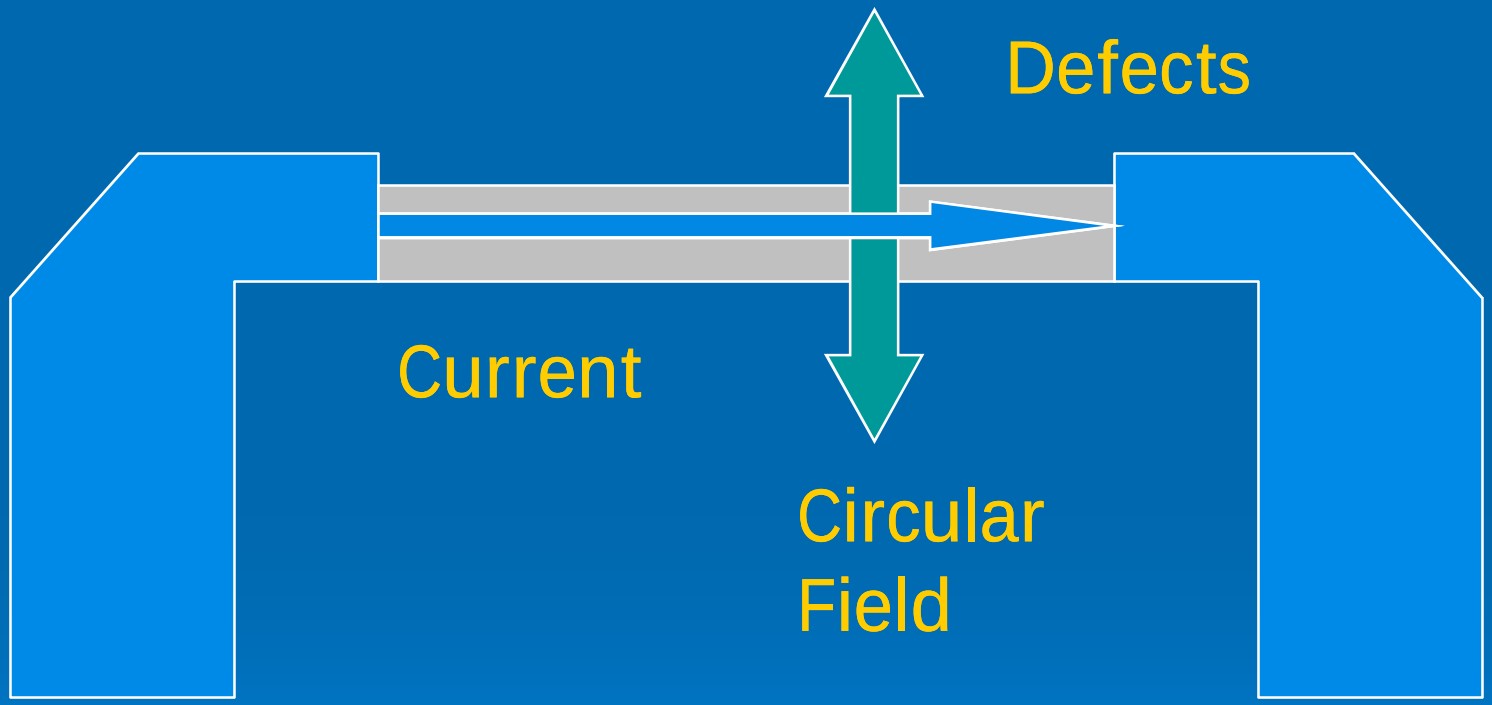
Current Flow

Current passed through sample



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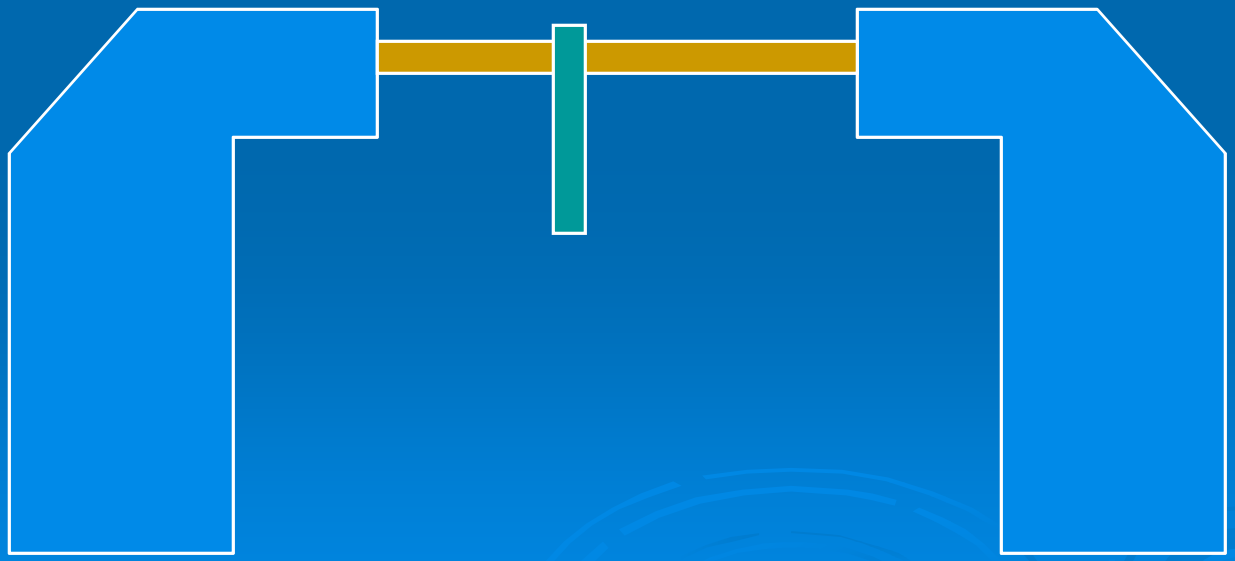
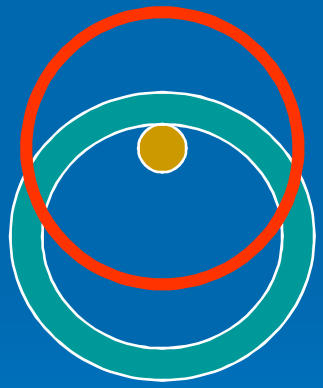
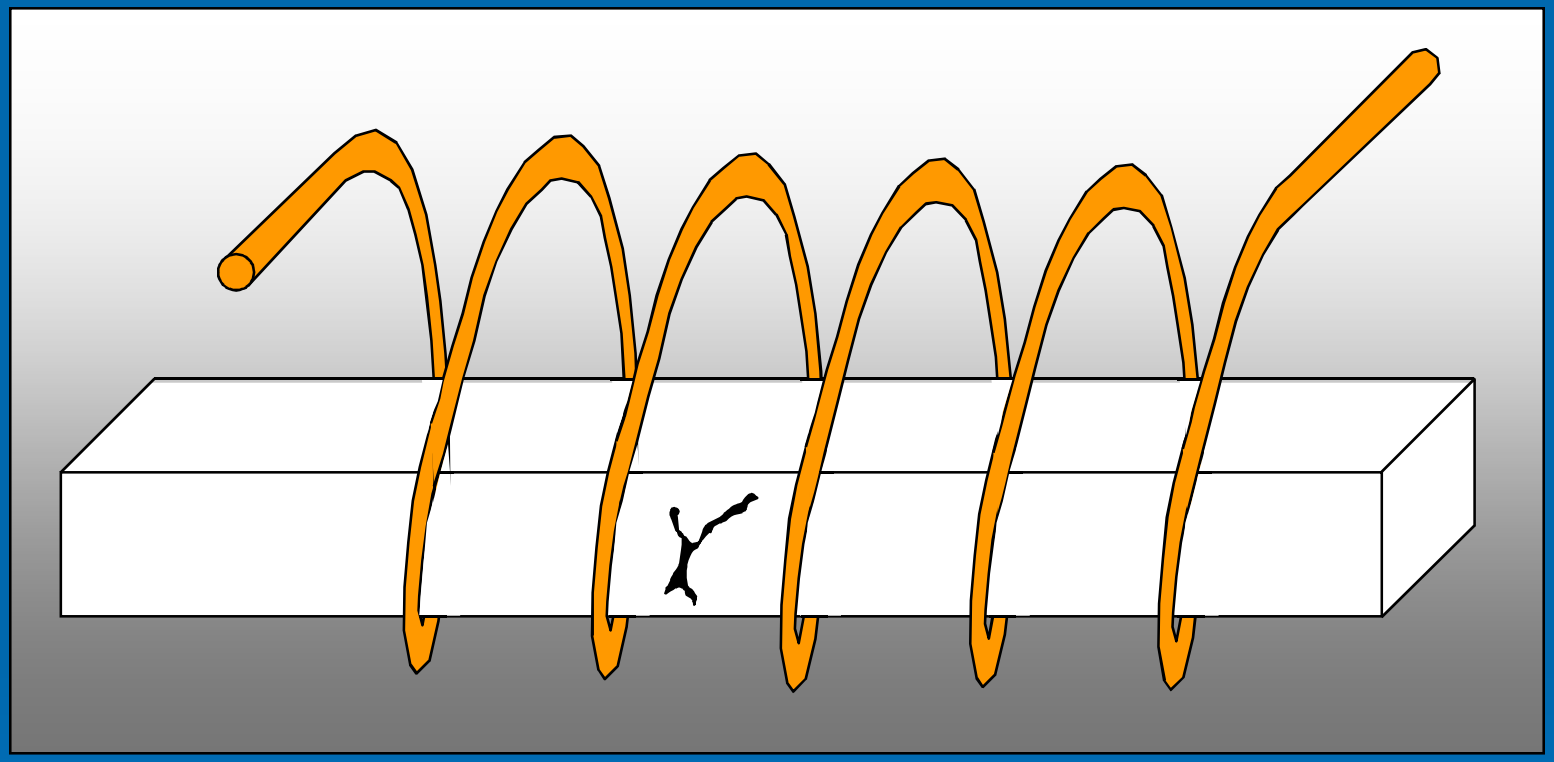
Threading Bar

- Current passed through brass bar placed between heads of bench unit
- Circular field generated around bar
- Sample hung from bar





Coil Magnetisation



- Changes circular field into longitudinal
- Increases the strength of the field

Magnetic Particle Inspection

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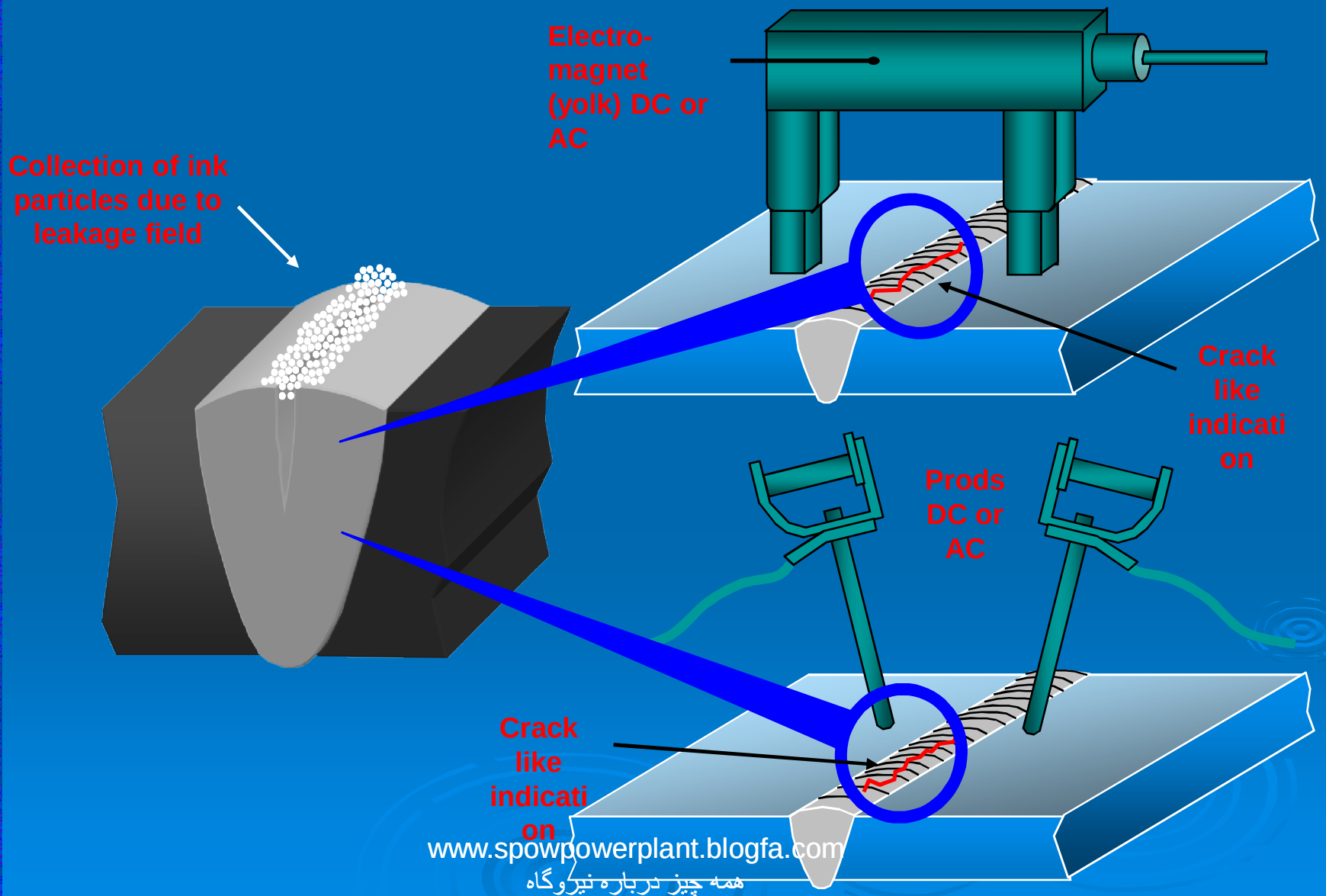
Magnetic Particle Inspection



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Magnetic Particle Inspection

A crack like indication

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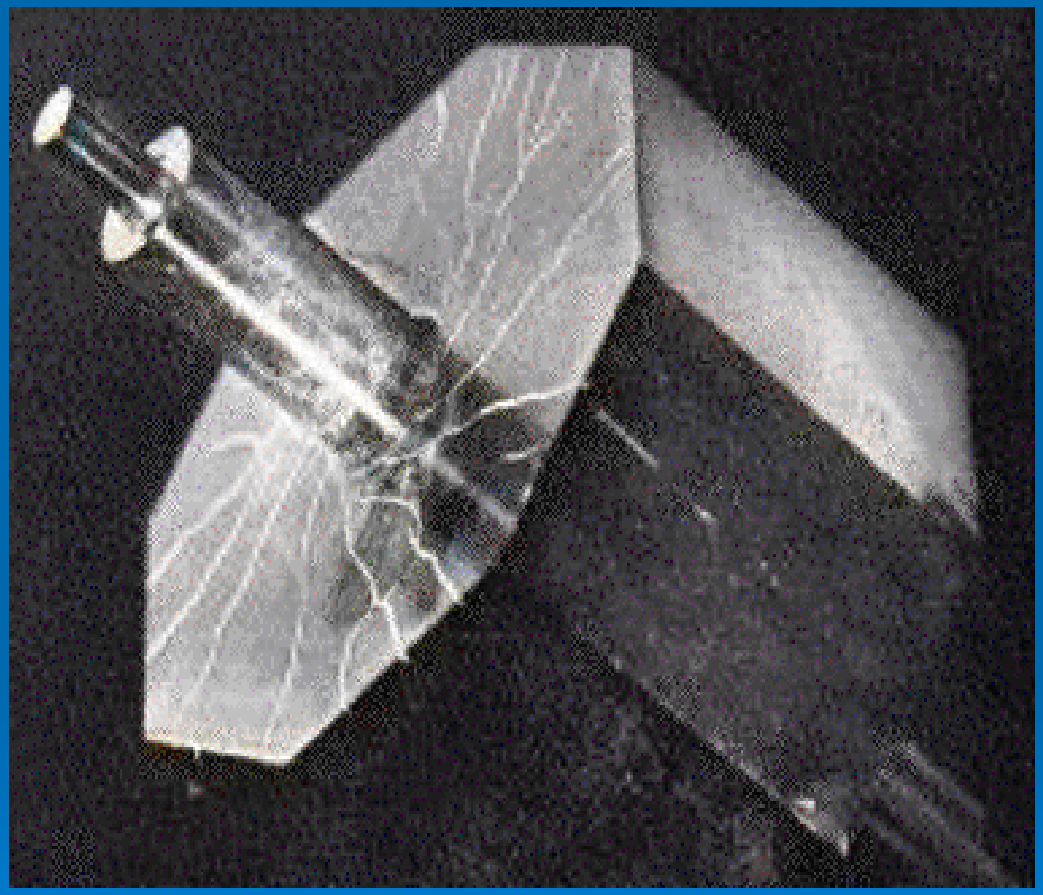
Magnetic Particle Inspection



Alternatively to contrast inks, fluorescent inks may be used for greater sensitivity. These inks require a UV-A light source and a darkened viewing area to inspect the component

Magnetic Particle Inspection

Typical sequence of operations to inspect a weld

- Clean area to be tested
- Apply contrast paint
- Apply magnetisism to the component
- Apply ferro-magnetic ink to the component during magnetising
- Interpret the test area
- Post clean and de-magnatise if required

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Magnetic Particle Inspection

- **Advantages**
- Simple to use
- Inexpensive
- Rapid results
- Little surface preparation required
- More sensitive than visual inspection

- **Disadvantages**
- Surface or slight sub-surface detection only
- Magnetic materials only
- No indication of defects depths
- Detection is required in two directions

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Basic Principles of Ultrasonic Testing

- To understand and appreciate the capability and limitation of UT

Ultrasonic Inspection

- Sub-surface detection
- This detection method uses high frequency sound waves, typically above 2MHz to pass through a material
- A probe is used which contains a piezo electric crystal to transmit and receive ultrasonic pulses and display the signals on a cathode ray tube or digital display
- The actual display relates to the time taken for the ultrasonic pulses to travel the distance to the interface and back
- An interface could be the back of a plate material or a defect
- For ultrasound to enter a material a couplant must be introduced between the probe and specimen

Ultrasonic Inspection

Ultrasonic testing is a good technique for the detection of plate laminations and thickness surveys

Laminations detected using compression probes

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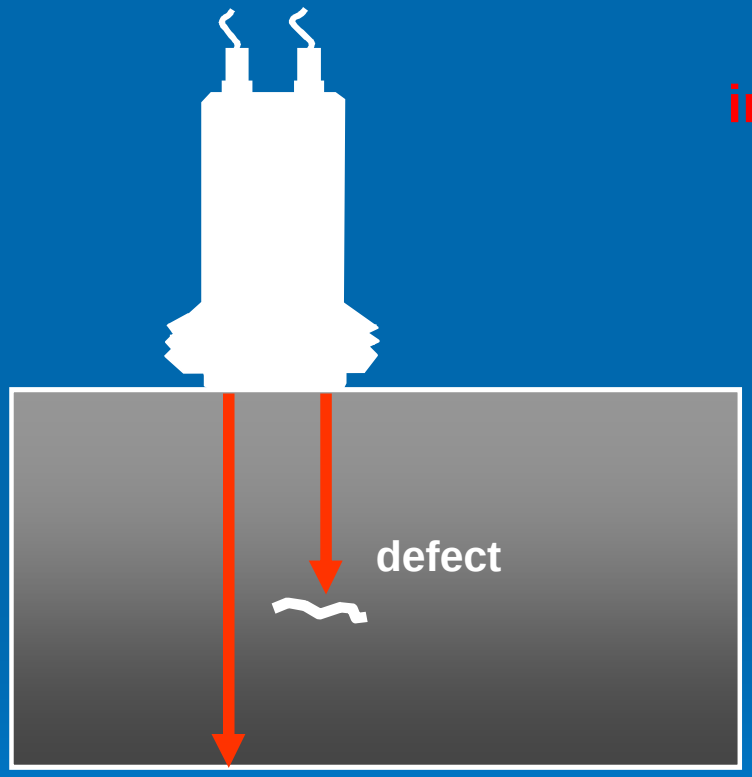
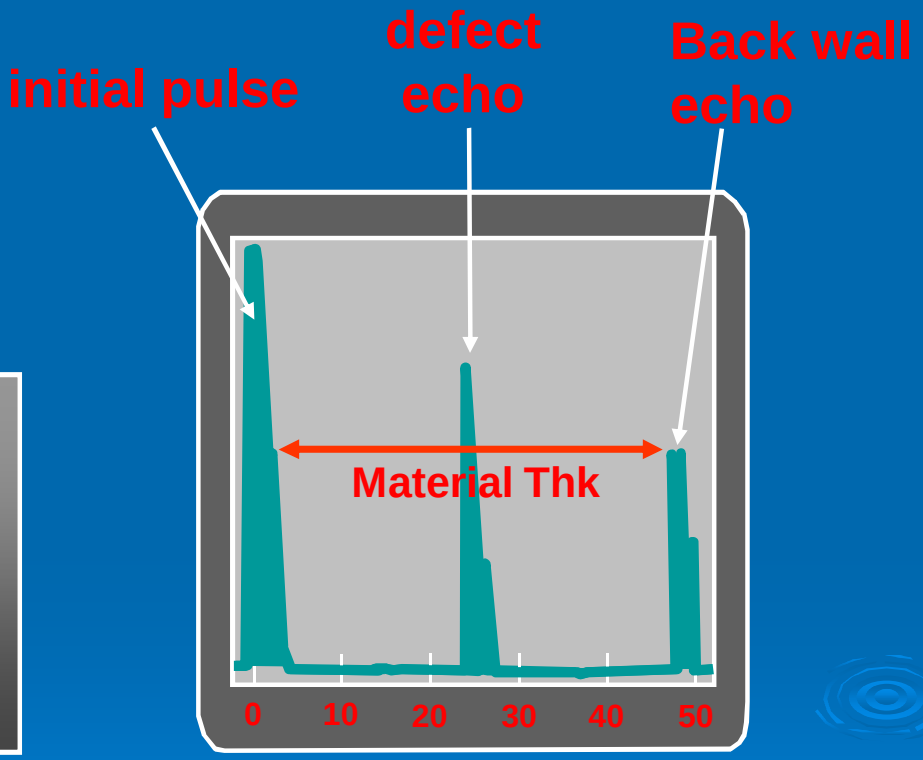
Ultrasonic Inspection



Compression Probe



CRT Display

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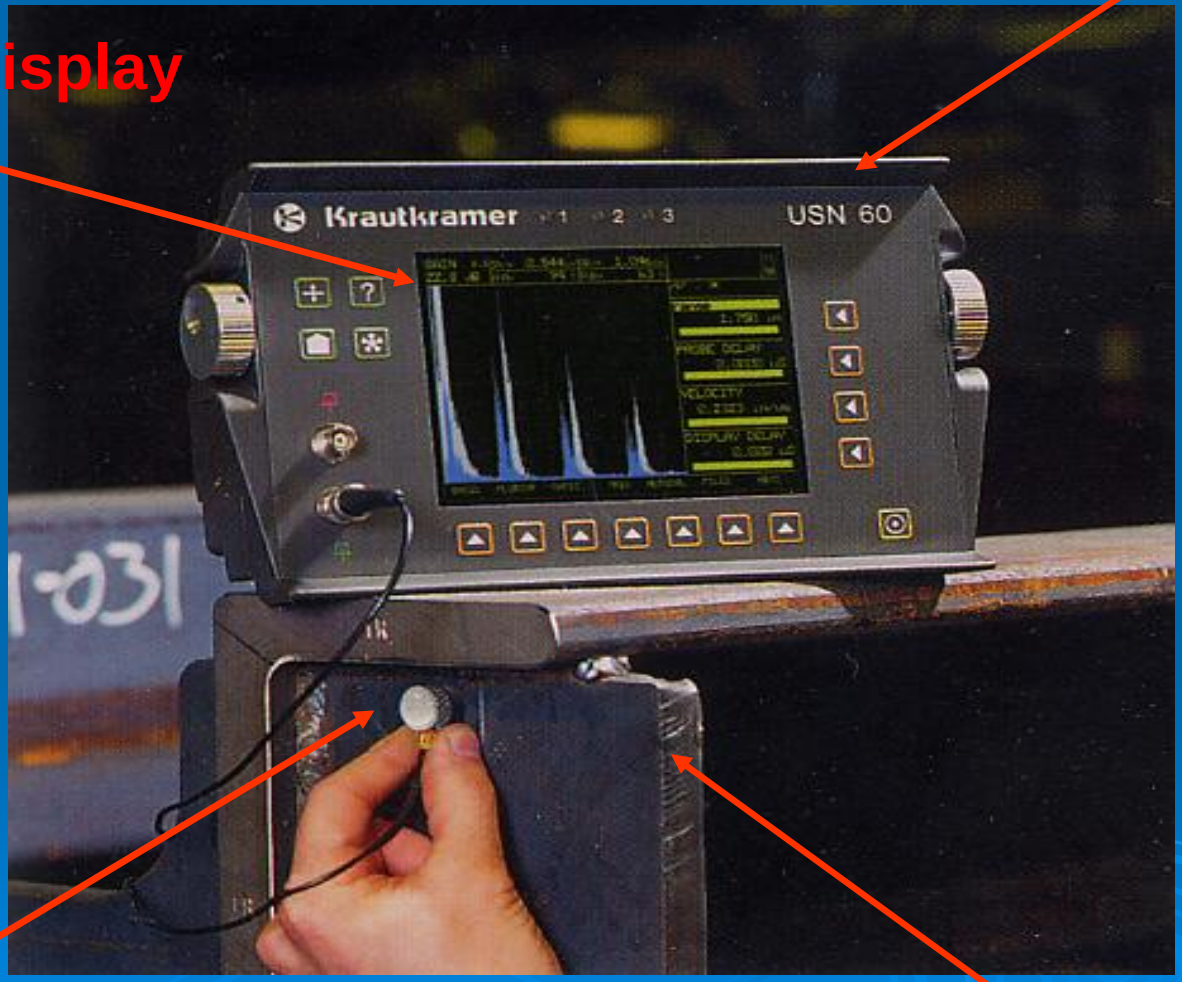
Ultrasonic Inspection

Pulse echo signals
A scan Display

UT Set, Digital



Compression probe

Thickness checking the material

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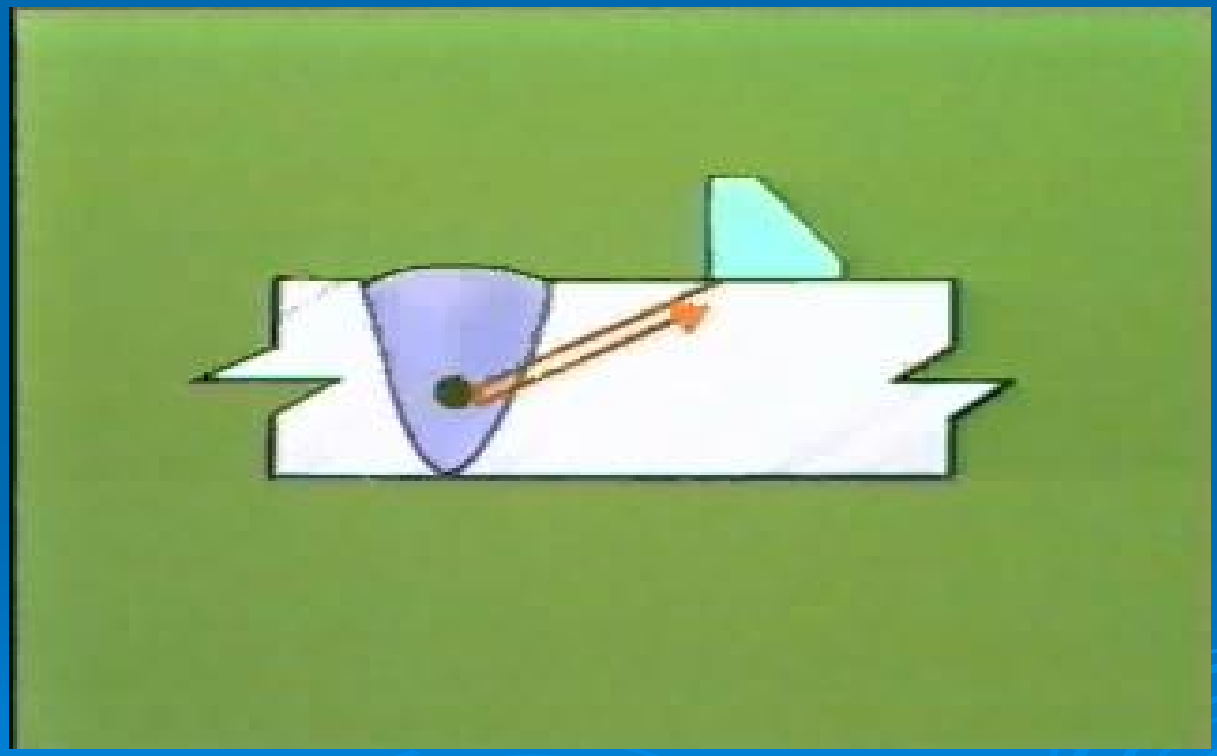
Ultrasonic Inspection

Ultrasonic testing requires high operator for defect identification



Most weld defects detected using angle probes

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Ultrasonic Inspection

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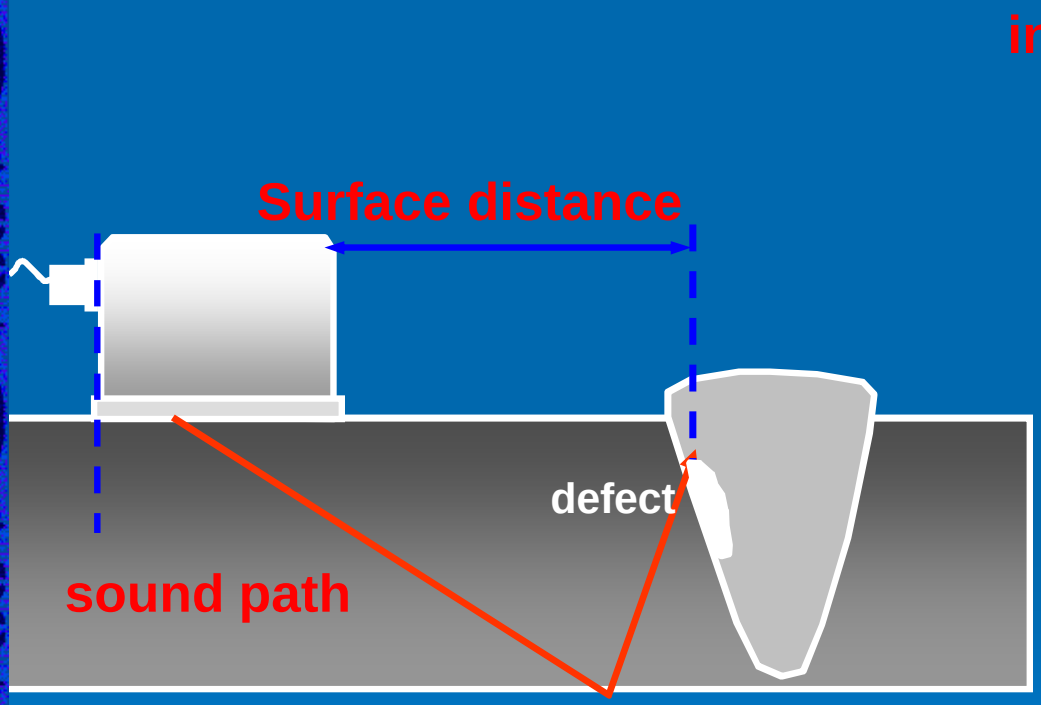
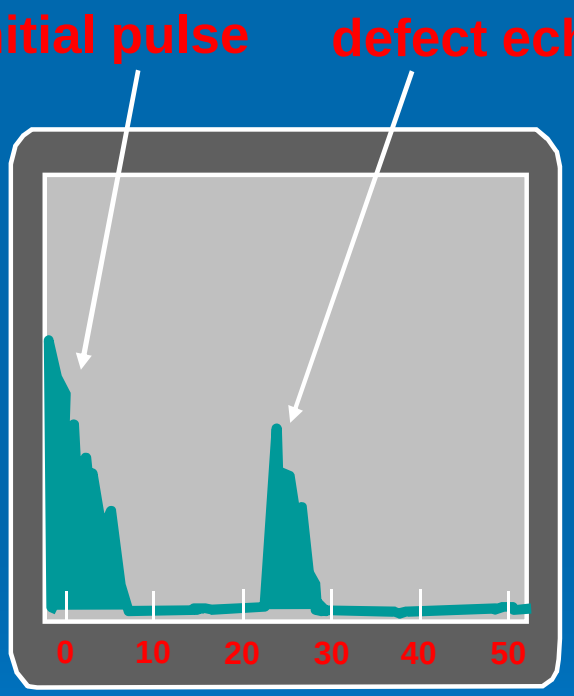
Ultrasonic Inspection



Angle Probe



CRT Display

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Ultrasonic Inspection

- **Advantages**
- Rapid results
- Sub-surface detection
- Safe
- Can detect planar defect
- Capable of measuring the depth of defects
- May be battery powered
- Portable

- **Disadvantages**
- Trained and skilled operator required
- Requires high operator skill
- Good surface finish required
- Difficulty on detecting volumetric defect
- Couplant may contaminate
- No permanent record

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EDDY CURRENT

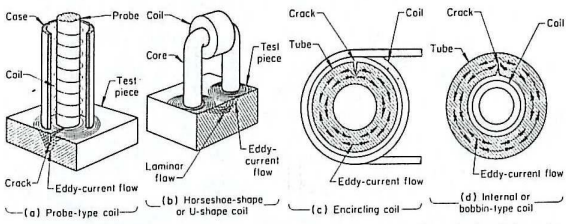

Fig. 23 Types and applications of coils used in eddy current inspection. (a) Probe-type coil applied to a flat plate for detection of a crack. (b) Horseshoe-shaped or U-shaped coil applied to a flat plate for detection of a laminar flaw. (c) Encircling coil applied to a tube. (d) Internal or bobbin-type coil applied to a tube

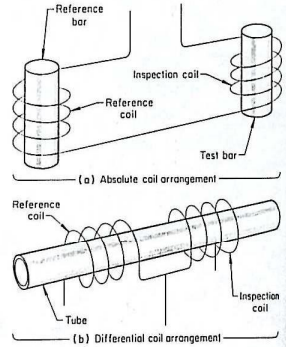

Fig. 24 Absolute and differential arrangements of multiple coils used in eddy current inspection. See text for discussion.

the flow of the eddy currents be as nearly perpendicular to the flaws as possible to obtain a maximum response from the flaws. If the eddy current flow is parallel to flaws, there will be little or no distortion of the currents and therefore very little reaction on the inspection coil.

Probe and Encircling Coils. Of the almost infinite variety of coils employed in eddy current inspection, probe coils and encircling coils are the most commonly used. Normally, in the inspection of a flat surface for cracks at an angle to the surface, a probe-type coil would be used because this type of coil induces currents that flow parallel to the surface and therefore across a crack, as shown in Fig. 23(a). On the other hand, a probe-type coil would not be suitable for detecting a laminar type of flaw. For such a discontinuity, a U-shaped or horseshoe-shaped coil, such as the one shown in Fig. 23(b), would be satisfactory.

To inspect tubing or bar, an encircling coil (Fig. 23c) is generally used because of complementary configuration and because of the testing speeds that can be obtained with this type of coil. However, an encircling coil is sensitive only to discontinuities that are parallel to the axis of the tube or bar. The coil is satisfactory for this particular application because, as a result of the manufacturing process, most discontinuities in tubing and bar are parallel to the major axis. If it is necessary to locate discontinuities that are not parallel to the axis, a probe coil must be used, and either the coil or the part must be rotated during scanning. To detect discontinuities on the inside surface of a tube or when testing installed tubing, an internal or bobbin-type coil (Fig. 23d) can be used. The bobbin-type coil, like the encircling coil, is sensitive to discontinuities that are parallel to the axis of the tube or bar.

Multiple Coils. In many setups for eddy current inspection, two coils are used. The two coils are normally connected to separate legs of an alternating current bridge in a series-opposing arrangement so that when their impedances are the same, there is no output from the pair. Pairs of coils can be used in either an absolute or a differential arrangement (Fig. 24).

Absolute Coil Arrangements. In the absolute arrangement (Fig. 24a), a sample of acceptable material is placed in one coil, and the other coil is used for inspection. Thus, the coils are comparing an unknown against a standard, with the differences between the two (if any) being indicated by a suitable instrument. Arrangements of this type are commonly employed in sorting applications.

Differential Coil Arrangement. In many applications, an absolute coil arrangement is undesirable. For example, in tubing inspection, an absolute arrangement will indicate dimensional variations in both outside diameter and wall thickness even though such variations may be well within allowable limits. To avoid this problem, a differential coil arrangement such as that shown in Fig. 24(b) can be used. Here, the two coils compare one section of the tube with an adjacent section. When the two sections are the same, there is no output from the pair of coils and therefore no indication on the eddy current instrument. Gradual dimensional variations within the tube or gross variations between individual tubes are not indicated, while discontinuities, which normally occur abruptly, are very apparent. In this way, it is possible to have an inspection system that is sensitive to flaws and relatively insensitive to changes that normally are not of interest.

Sizes and Shapes. Inspection coils are available in a variety of sizes and shapes. Selection of a coil for a particular application depends on the type of discontinuity. For example, when an encircling coil is used to inspect tubing or bar for short discontinuities, optimum resolution is obtained with a short coil. Alternatively, a

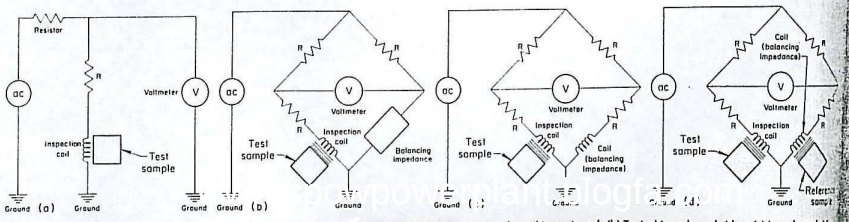

Fig. 25 Four types of eddy current instruments. (a) A simple arrangement, in which voltage across the coil is monitored. (b) Typical impedance bridge. (c) Impedance bridge with dual coils. (d) Impedance bridge with dual coil, and reference sample in the second coil

EDDY CURRENT

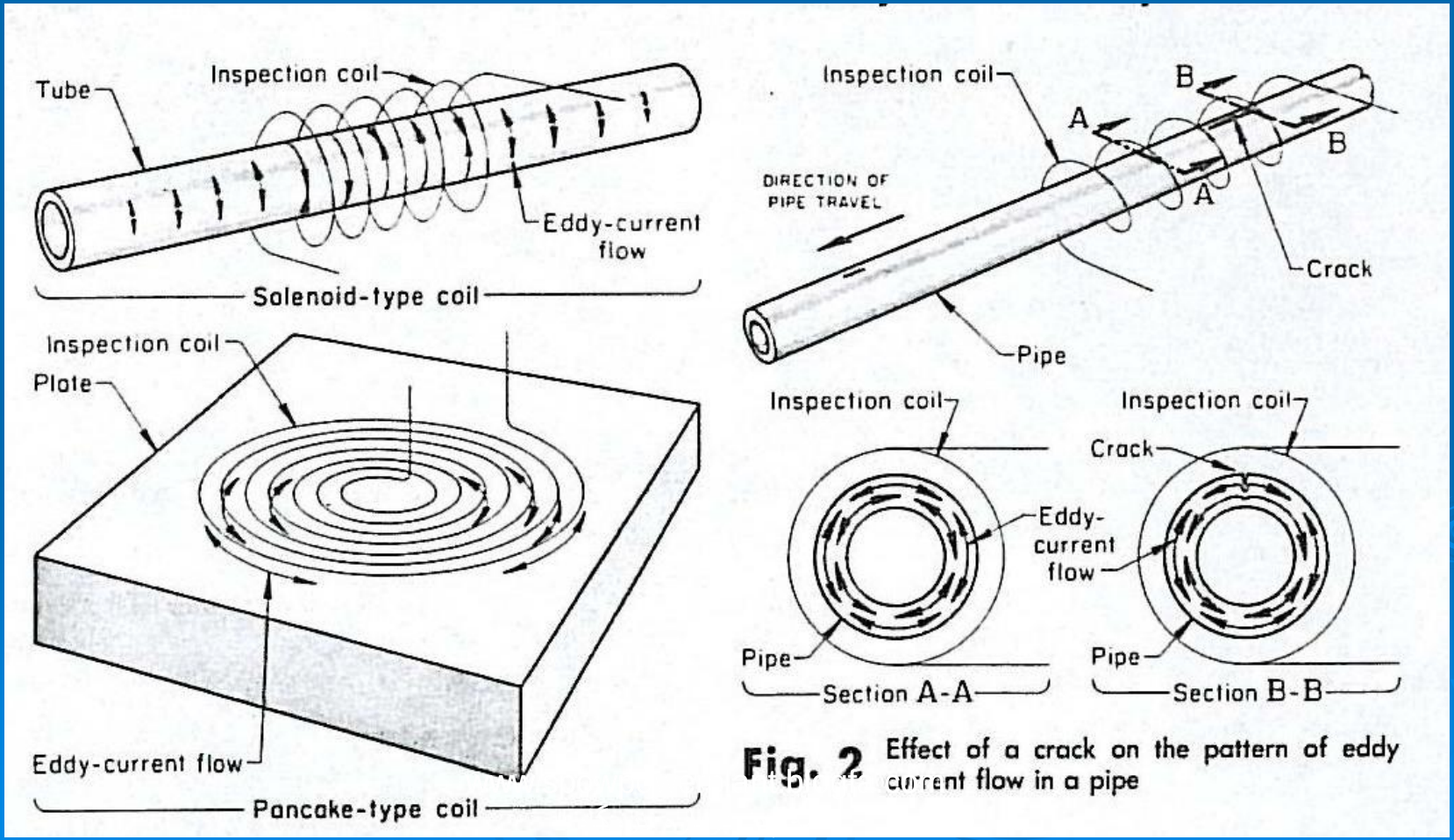

Fig. 2 Effect of a crack on the pattern of eddy current flow in a pipe

EDDY CURRENT

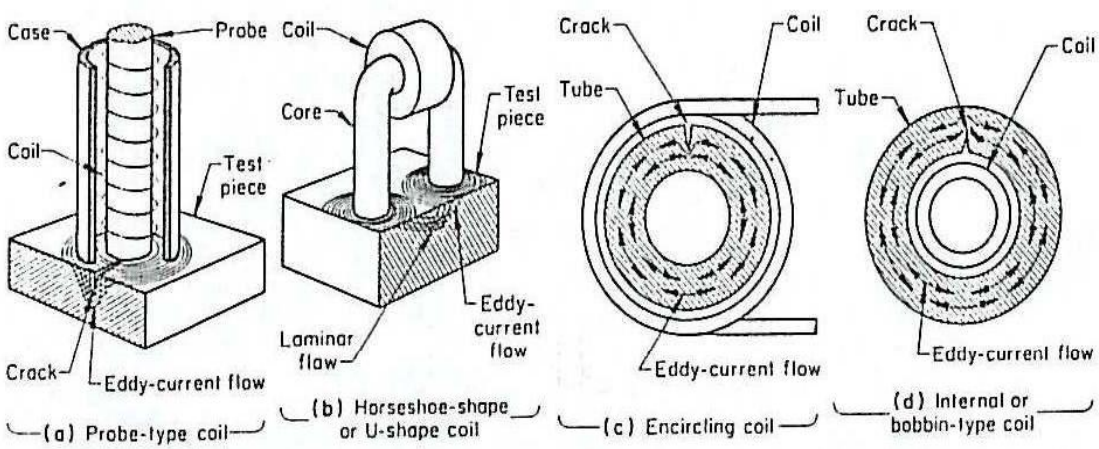

Fig. 23 Types and applications of coils used in eddy current inspection. (a) Probe-type coil applied to a flat plate for detection of a crack. (b) Horseshoe-shaped or U-shaped coil applied to a flat plate for detection of a laminar flaw. (c) Encircling coil applied to a tube. (d) Internal or bobbin-type coil applied to a tube

the flow of the eddy currents be as nearly perpendicular to the flaws as possible to obtain a maximum response from the flaws. If the eddy current flow is parallel to flaws, there will be little or no distortion of the currents and therefore very little reaction on the inspection coil.

continuities that are not parallel to the axis, a probe coil must be used, and either the coil or the part must be rotated during scanning. To detect discontinuities on the inside surface of a tube or when testing installed tubing, an internal or bobbin-type coil (Fig. 23d) can be used. The bobbin-type

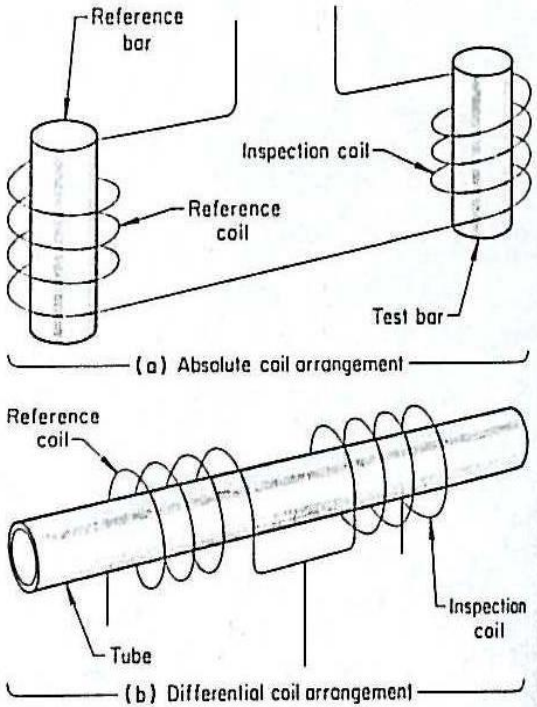

Fig. 24 Absolute and differential arrangements of multiple coils used in eddy current inspection. See text for discussion.

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EDDY CURRENT

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Radiographic Inspection

The principles of radiography

- X or Gamma radiation is imposed upon a test object
- Radiation is transmitted to varying degrees dependant upon the density of the material through which it is travelling
- Thinner areas and materials of a less density show as darker areas on the radiograph
- Thicker areas and materials of a greater density show as lighter areas on a radiograph
- Applicable to metals,non-metals and composites

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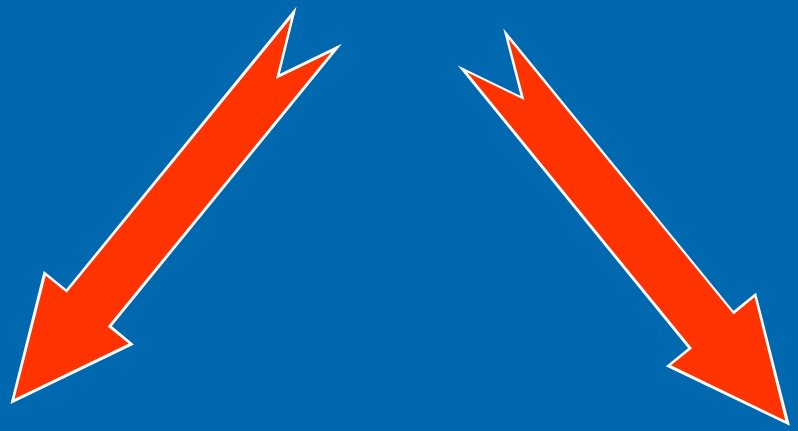
Industrial Radiography



- X - Rays
  Electrically generated
- Gamma Rays
  Generated by the decay of unstable atoms

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Industrial Radiography

- X - Rays

  Electrically generated

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Industrial Radiography

- Gamma Rays

  Generated by the decay of unstable atoms

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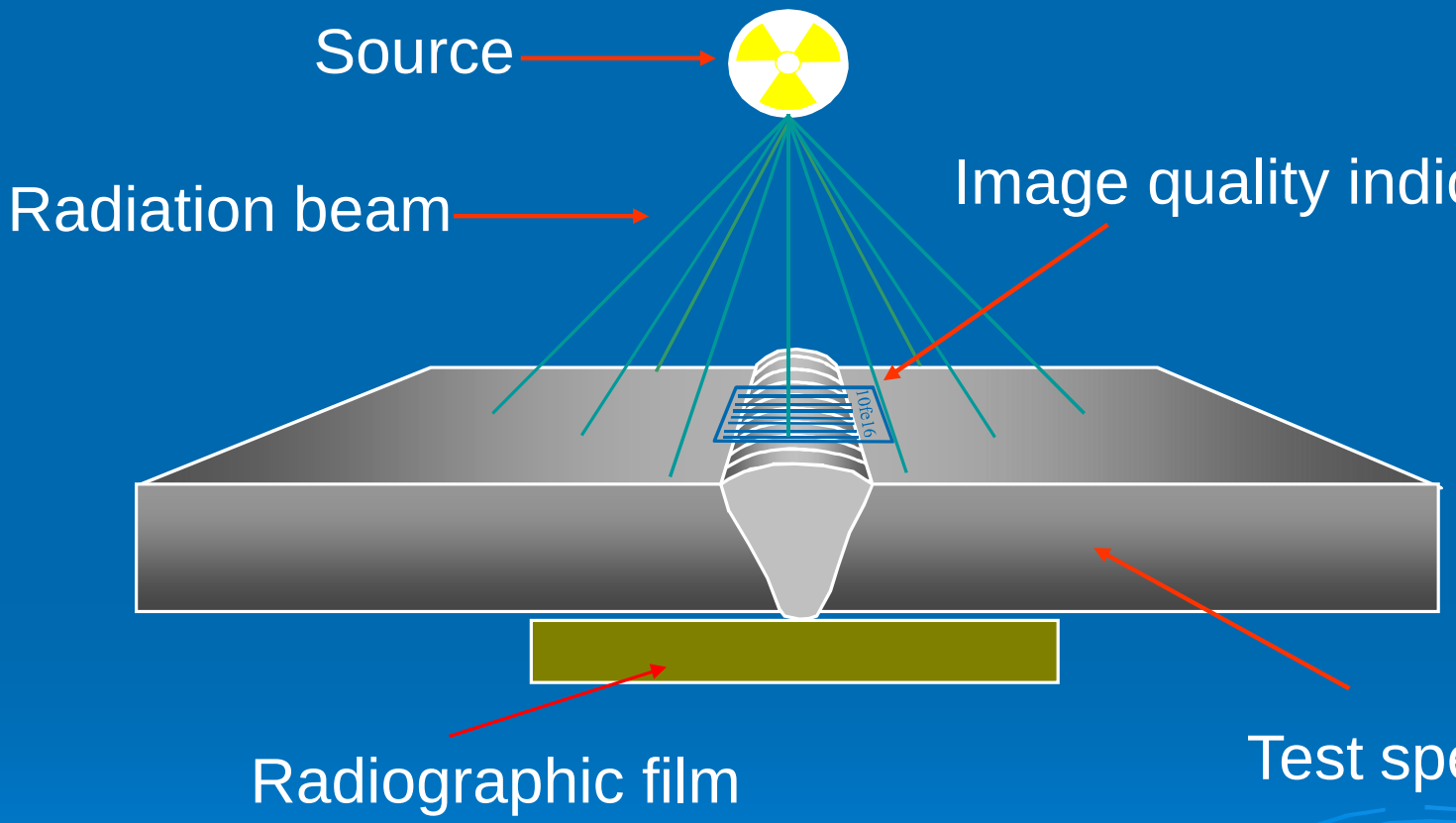
Radiographic Inspection



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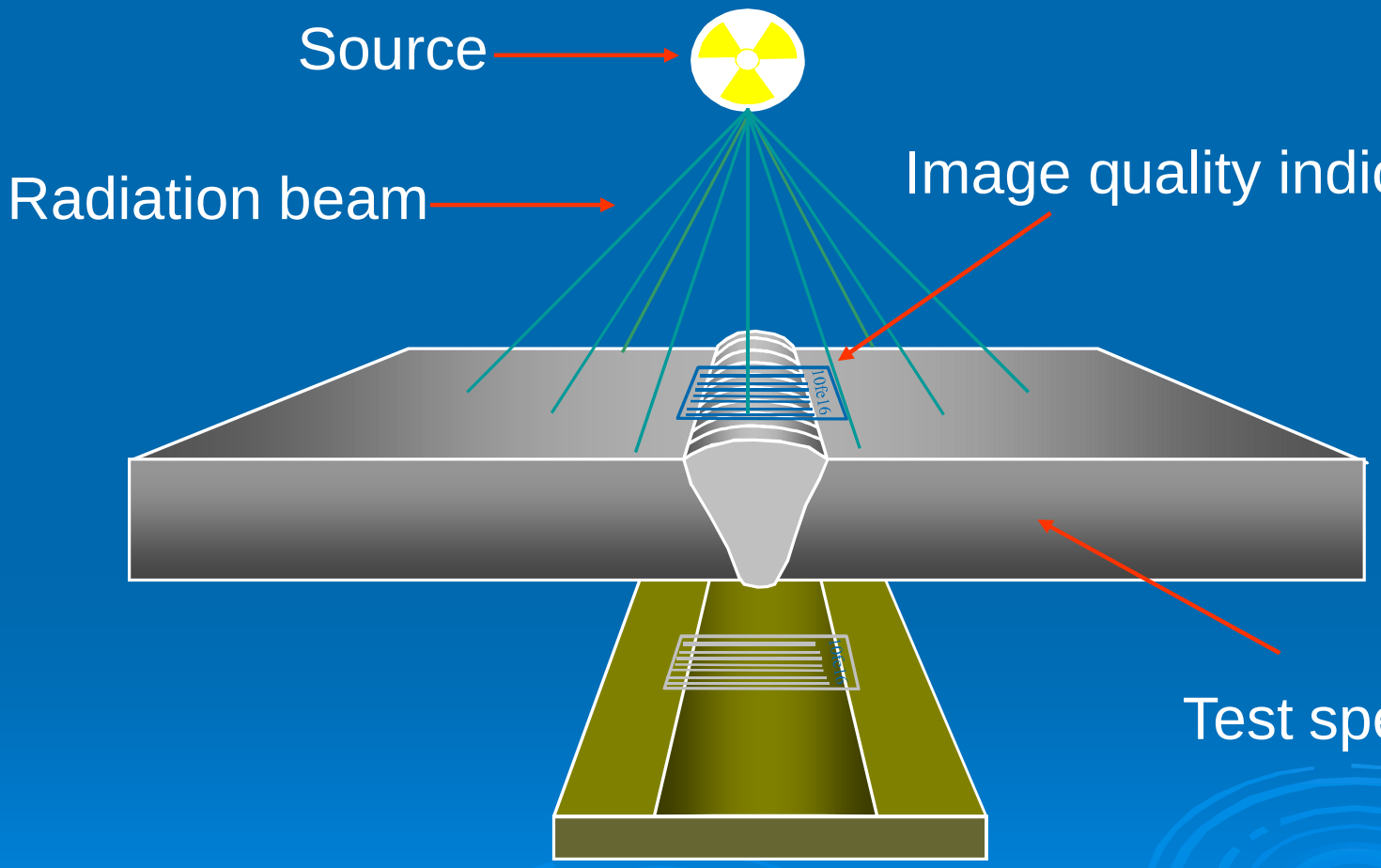
Radiographic Inspection



Radiographic film with latent image after exposure

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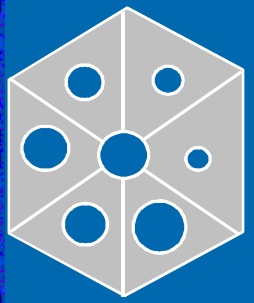
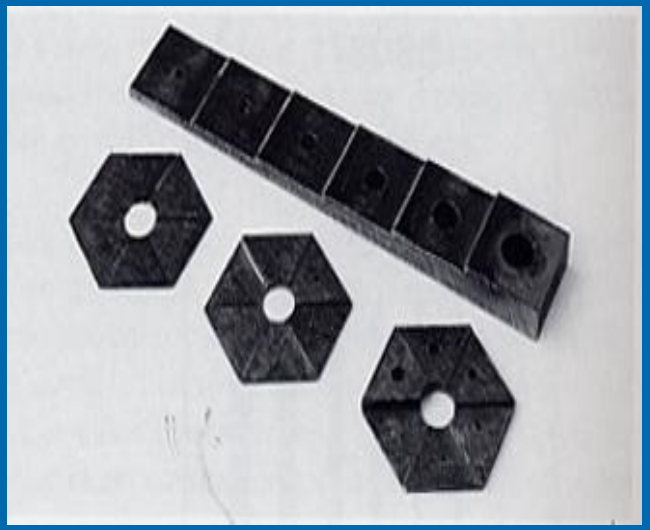
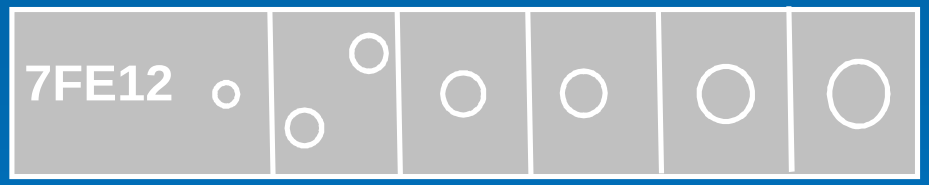
Radiographic Sensitivity







Step / Hole type IQI

Wire type IQI

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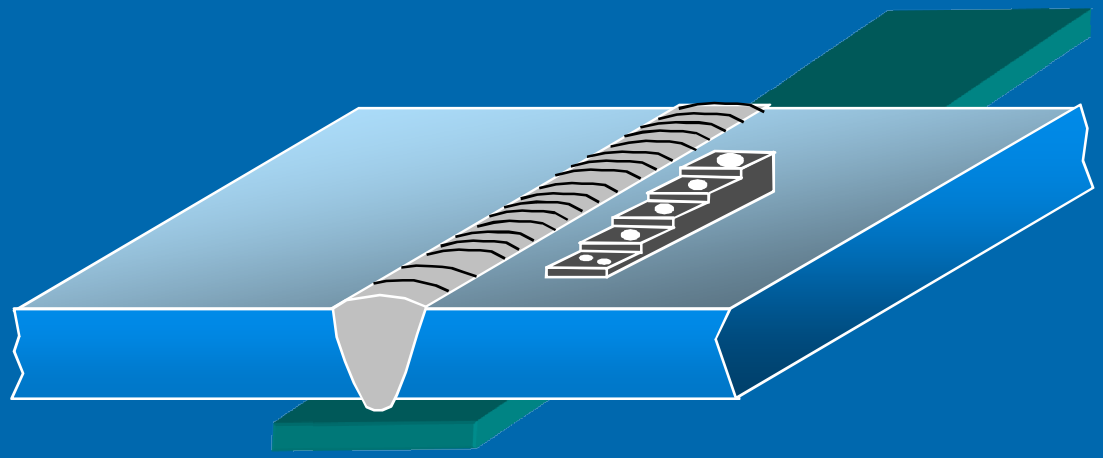
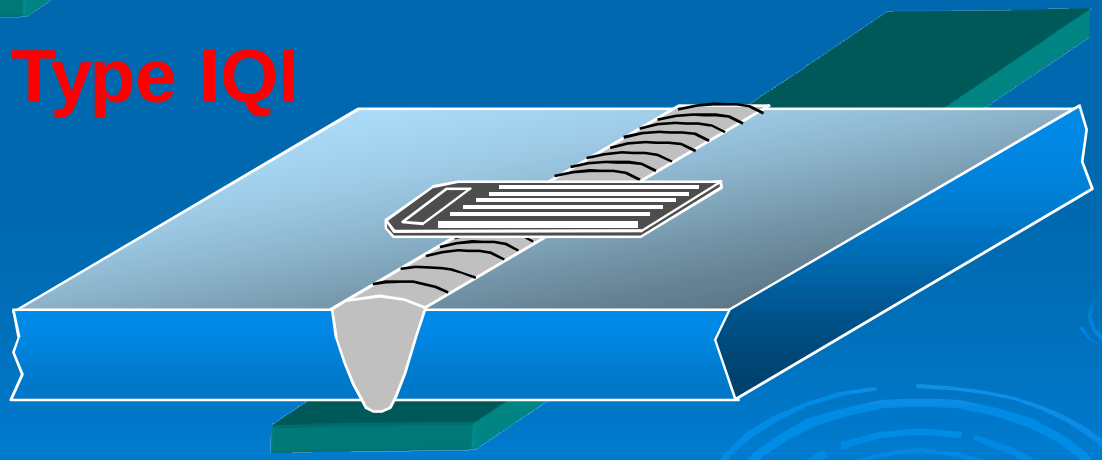
Image Quality Indicators



Step/Hole Type IQI



Wire Type IQI

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Radiographic Techniques

- Single Wall Single Image (SWSI)
  - film inside, source outside
- Single Wall Single Image (SWSI) panoramic
  - film outside, source inside (internal exposure)
- Double Wall Single Image (DWSI)
  - film outside, source outside (external exposure)
- Double Wall Double Image (DWDI)
  - film outside, source outside (elliptical exposure)

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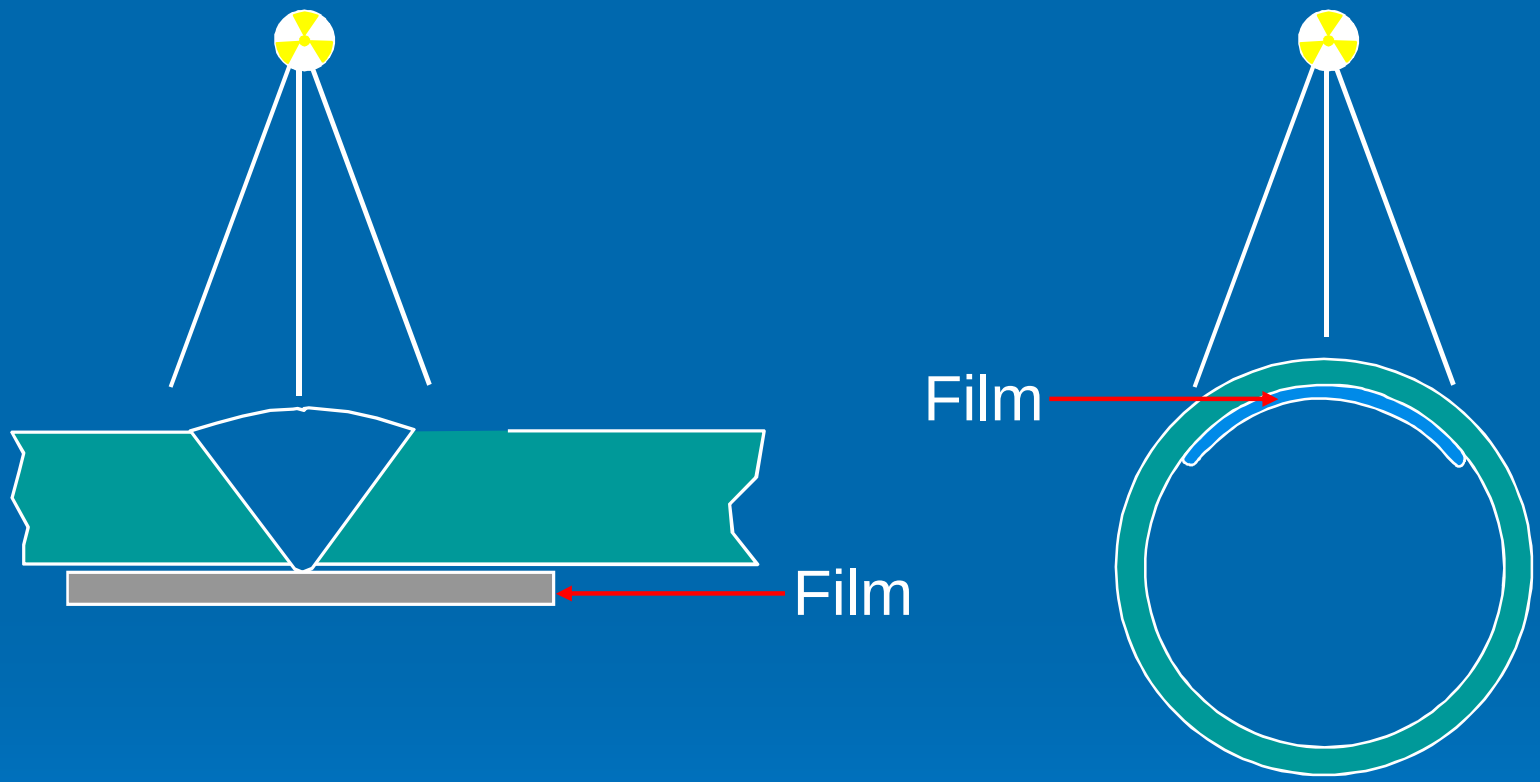
Single wall single image SWSI



IQI’s should be placed source side

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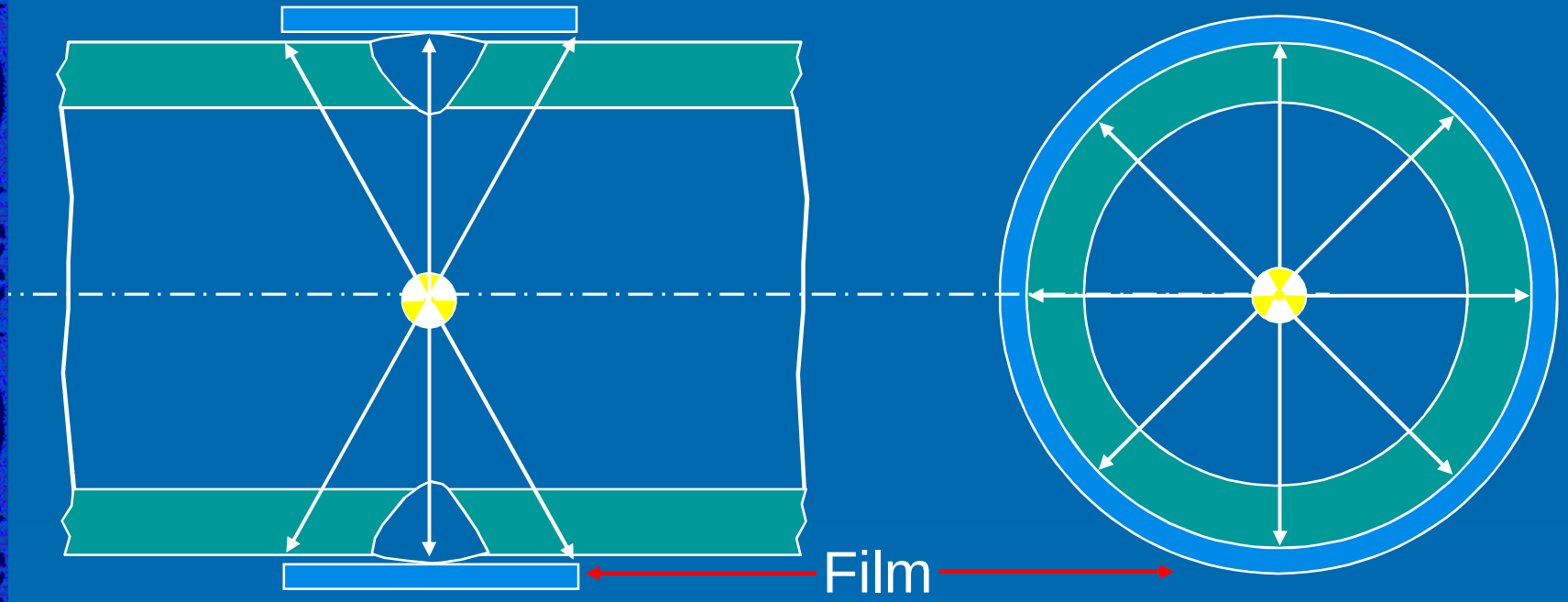
Single wall single image SWSI panoramic



- IQI’s are placed on the film side
- Source inside film outside (single exposure)

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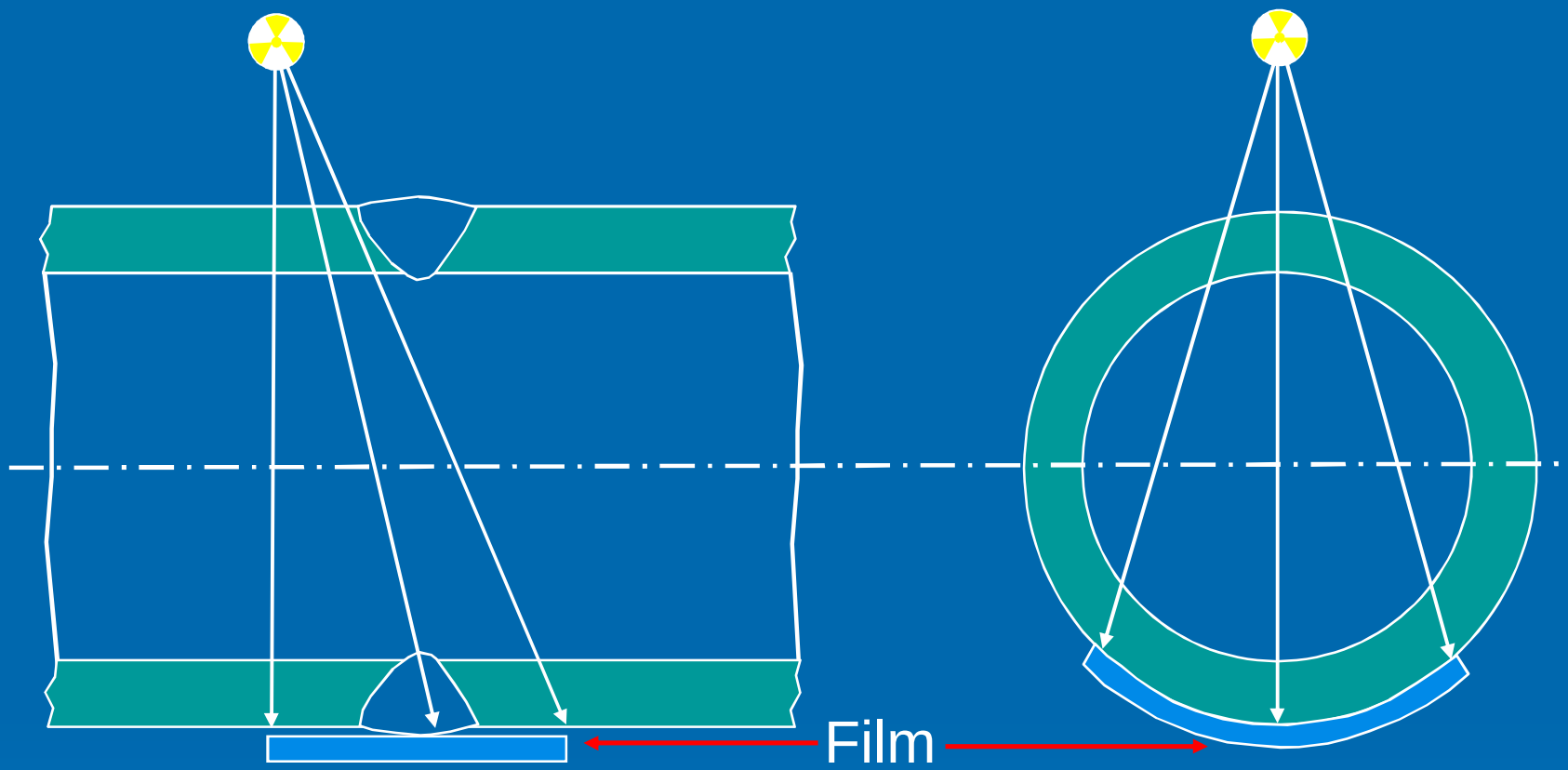
Double wall single image DWSI



- IQI's are placed on the film side
- Source outside film outside (multiple exposure)
- This technique is intended for pipe diameters over 100mm

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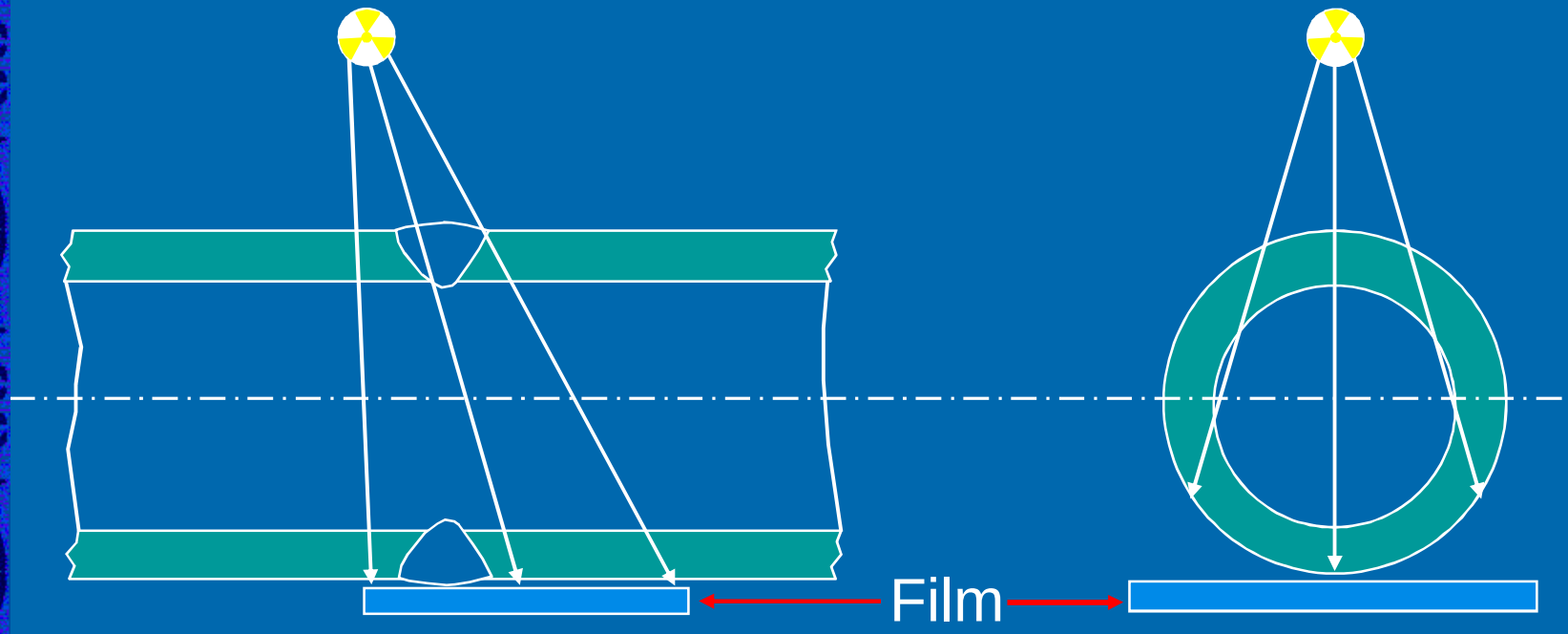
Double wall double image DWDI elliptical exposure



- IQI's are placed on the source or film side
- Source outside film outside (multiple exposure)
- A minimum of two exposures
- This technique is intended for pipe diameters less than 100mm

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Radiographic Inspection

- **Advantages**
- Permanent record
- Little surface preparation
- Defect identification
- No material type limitation

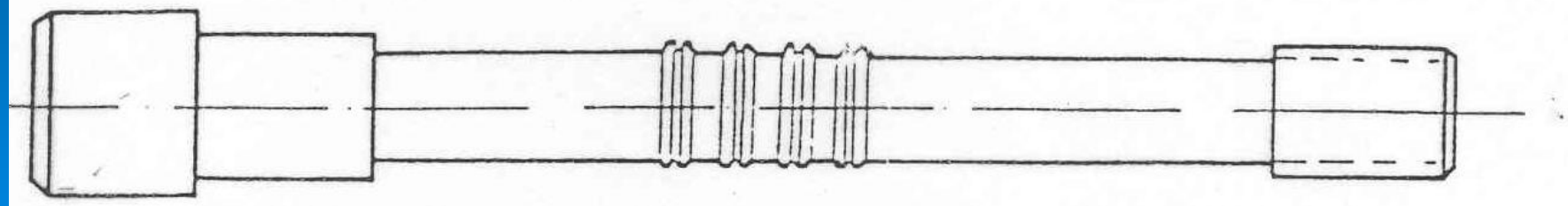
- **Disadvantages**
- Expensive equipment
- Bulky equipment (x-ray)
- Harmful radiation
- Detection on defect depending on orientation
- Slow results
- Required license to operate

به نام خدا

روشهای بازرسی اجزای توربین گازی زیمنس V94.2

Tie Rod

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	entfetten / Farbschicht entfernen *degrease / remove paint*	gesamte Oberflache *total surface*	MP *MT*	TWP 1017 *TWP 1017*
2	entfetten / Farbschicht entfernen *degrease / remove paint*	gesamtes Volumen *total volume*	US *UT*	TWP 1096 *TWP 1096*

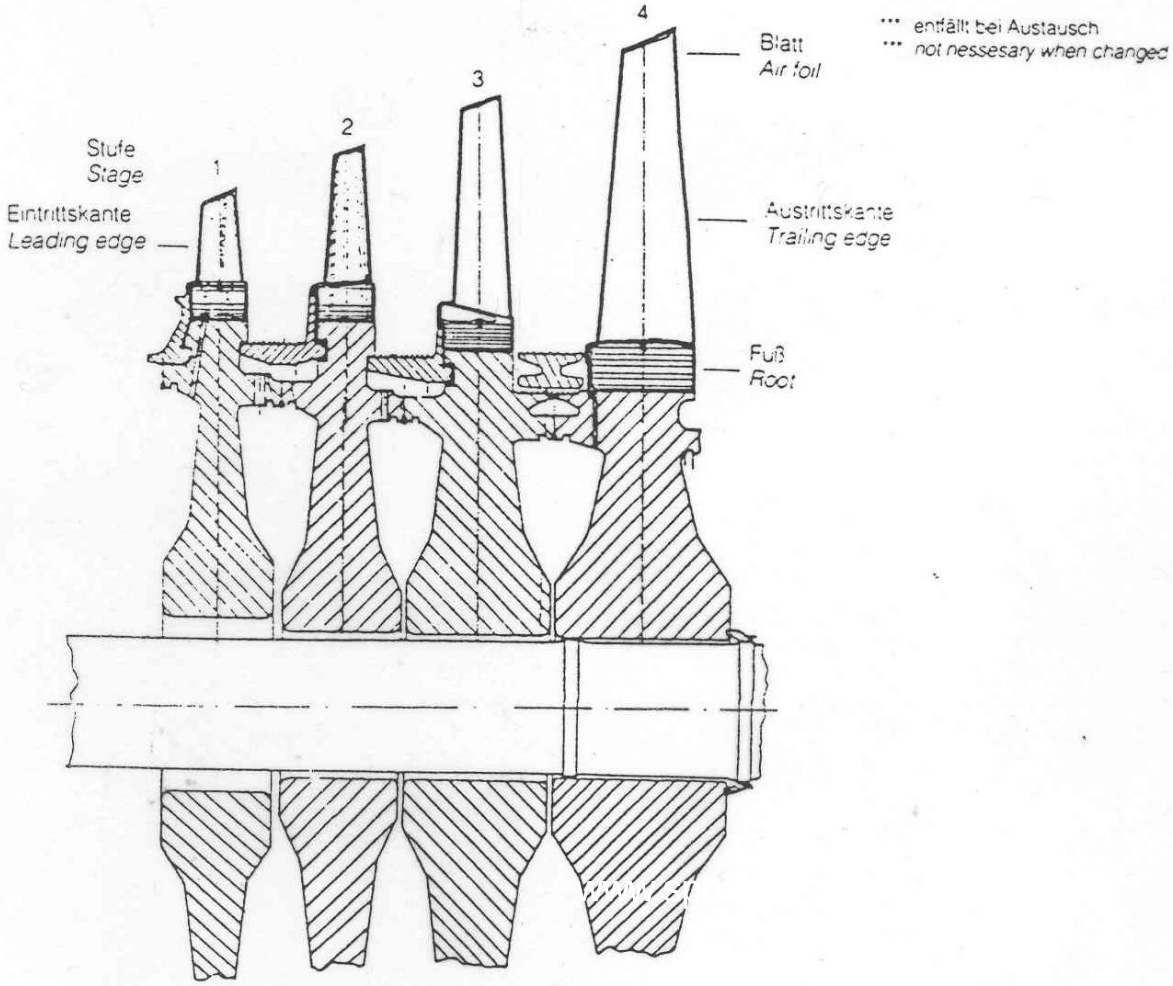


1	—	Schaufelblatt - Stufe 1 - 4*** *Air foil - stage - 1 - 4******	SK *VT*PT*	
2	Beläge entfernen *remove deposits*	Austrittskante - Stufe 1 - 4*** *Trailing edge - stage 1 - 4****	WS ** *ET **	TWP 1018 *TWP 1018*
3	entfetten *degrease*	Schaufelfuß - Stufe 1 - 4 *) *** *Blade root - stage 1 - 4 *) ****	WS ** ET **	TWP 1018 *TWP 1018*

* Ausbau erforderlich
* *Blade removal required*

** sofern nicht beschichtet
** *If not coated*

*** entfällt bei Austausch
*** *not nessesary when changed*



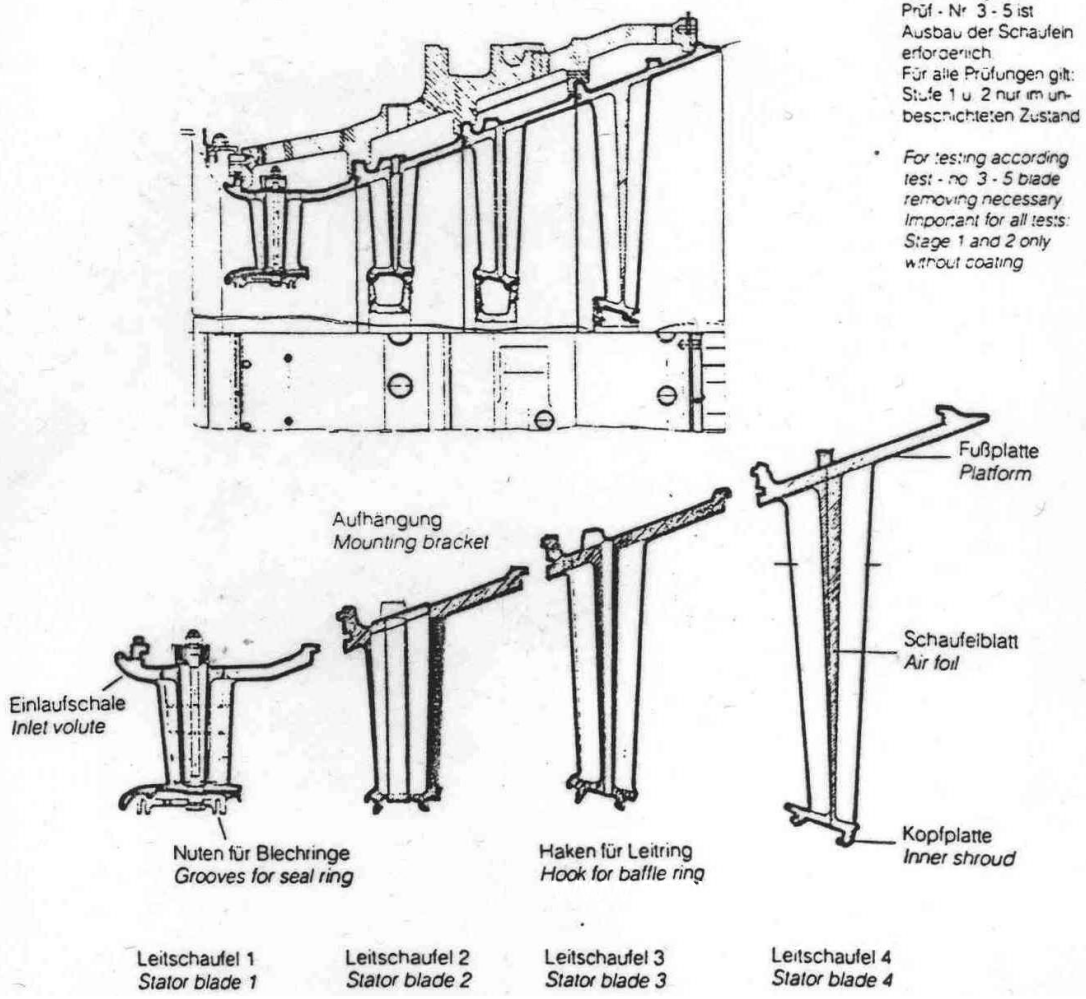
Turbine rotor blades

Turbin stator blades

1	–	Blatt komplett (alle Stufen) *Air foil complete (all stages)*	SK VT, PT
2	–	Fußplatte und Kopfplatte komplett (alle Stufen) *Platform and inner shroud complete (all stages)*	SK VT, PT
3	–	Kopfplatte Stufe 1 - [illegible] Blechring *Inner shroud - platform (grooves for seal strips)*	SK* VT, PT
4	–	Kopfplatte - Fußplatte - Nuten für Dichtblech (alle Stufen) *Inner shroud - platform - grooves for seal strips (all stages)*	SK* VT, PT
5	–	Verhakung an Kopf- und Fußplatte *Hooks on inner shroud and platform*	SK* VT, PT

* Für Prüfung nach Prüf - Nr 3 - 5 ist Ausbau der Schaufeln erforderlich
Für alle Prüfungen gilt: Stufe 1 u. 2 nur im unbeschichteten Zustand

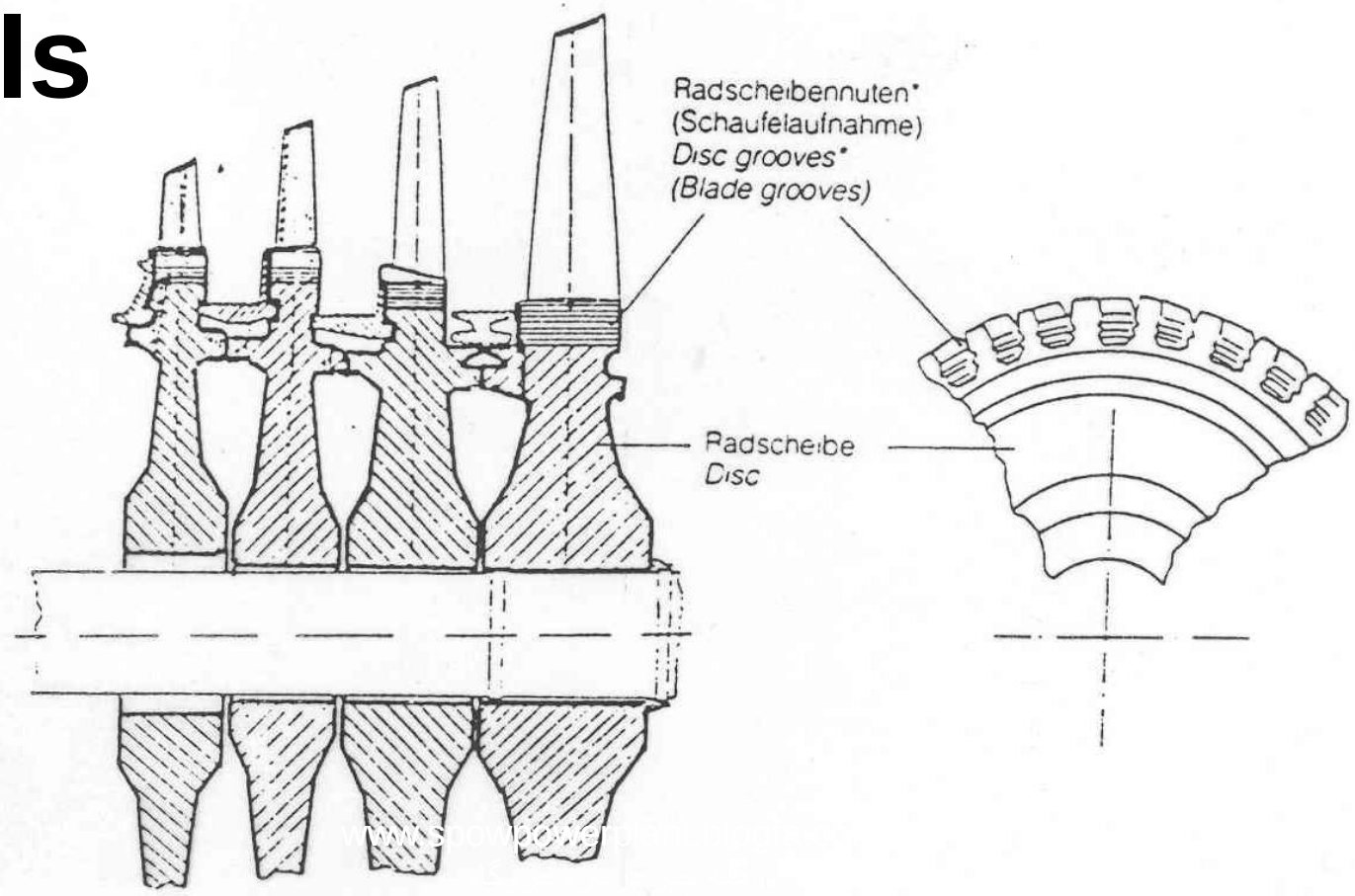
* *For testing according test - no 3 - 5 blade removing necessary*
Important for all tests: Stage 1 and 2 only without coating



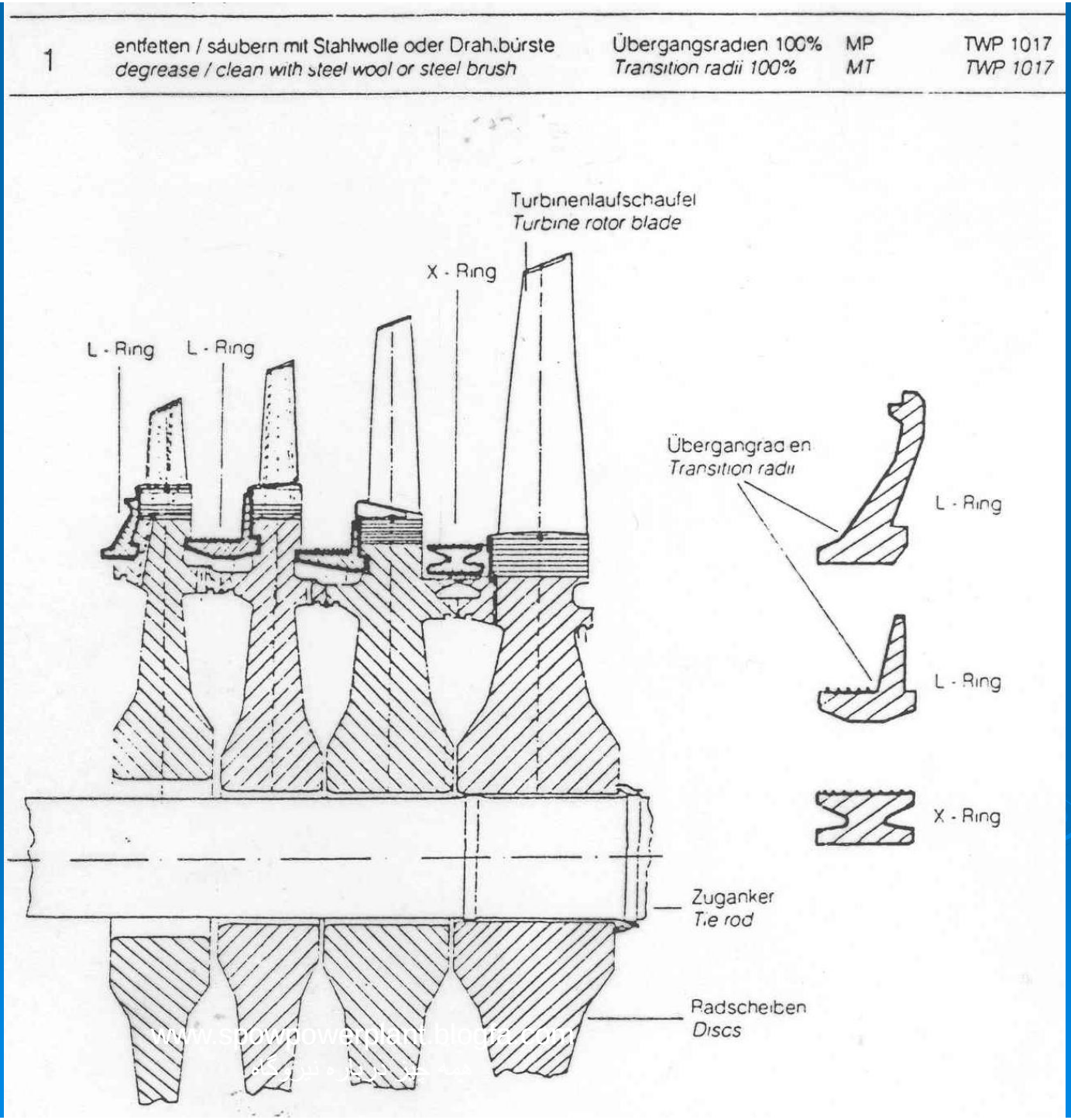
Turbine wheels

1	entfetten / Beläge entfernen (Drahtbürste) *degrease / remove deposits (wire brush)*	Radscheibennuten / Schaufelaufnahme * *Disc grooves / blade grooves **	MP *MT*	TWP 1017 *TWP 1017*
2	entfetten / Beläge entfernen (Drahtbürste) *degrease / remove deposits (wire brush)*	Radscheibennuten / Schaufelaufnahme * *Disc grooves / blade grooves **	Fe *PT*	TWP 1019 *TWP 1019*

* Ausbau der Schaufeln erforderlich
* *Blade removal required*

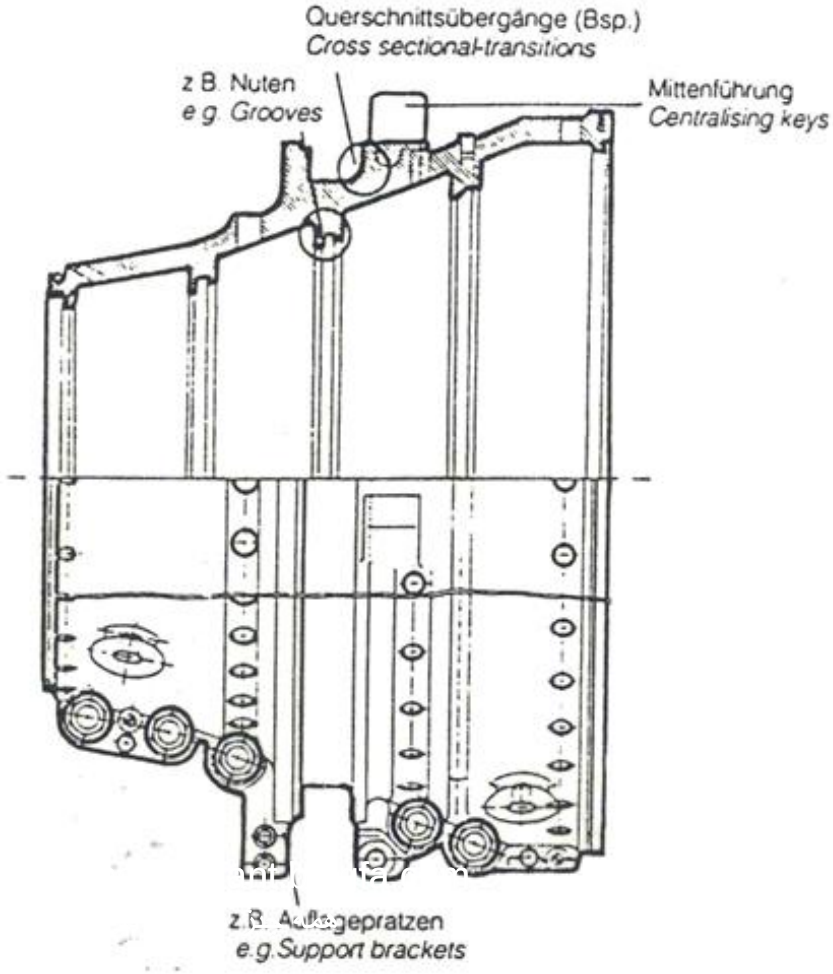


Turbine rings (L-and X-rings)



Turbine stator blade carrier

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	*Test method*	*Test specification*
1	entfetten *degrease*	Nuten *Grooves*	SK *VT & MT*	
2	entfetten / ggf. beschleifen *degrease / grind, if reqd*	Querschnittsübergänge *Cross sectional - transitions*	SK *VT & MT*	
3	entfetten / ggf. beschleifen *degrease / grind, if reqd.*	Mittenführung *Centralising keys*	SK *VT & MT*	

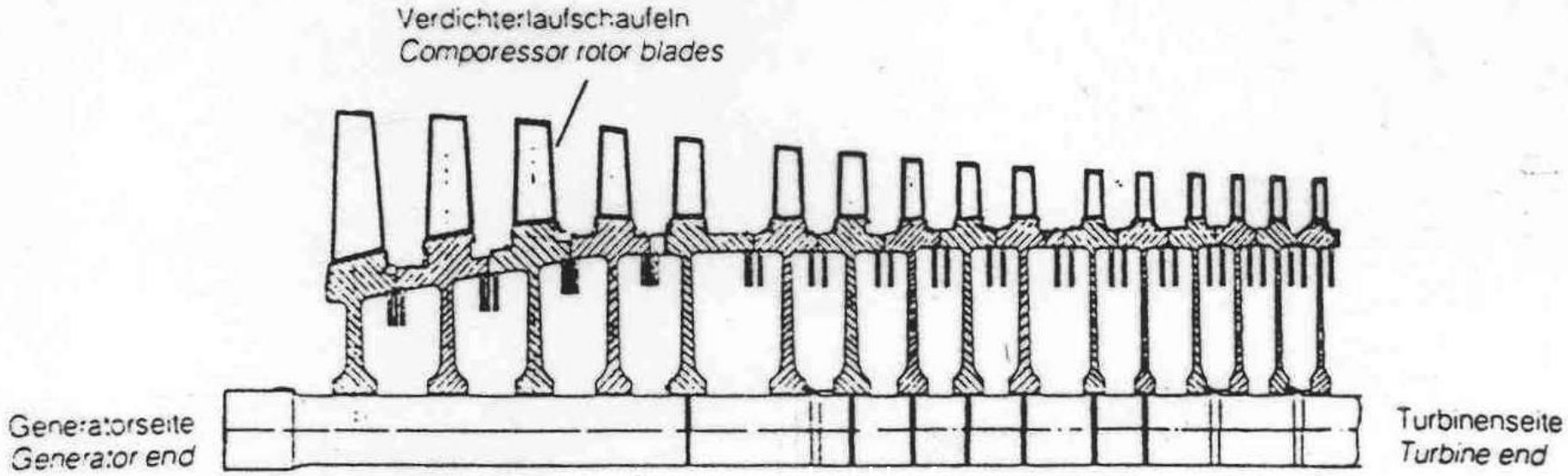


Compressor rotor blades

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	Belage entfernen / Sandstrahlen* *remove deposits / sandblasting**	Schaufelblatt - alle Stufen *Airfoil - all stages*	MP *MT*	TWP 1017 *TWP 1017*

* nicht an beschichteten Schaufeln

* *no sandblasting on coated blades*



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Compressor stator blades

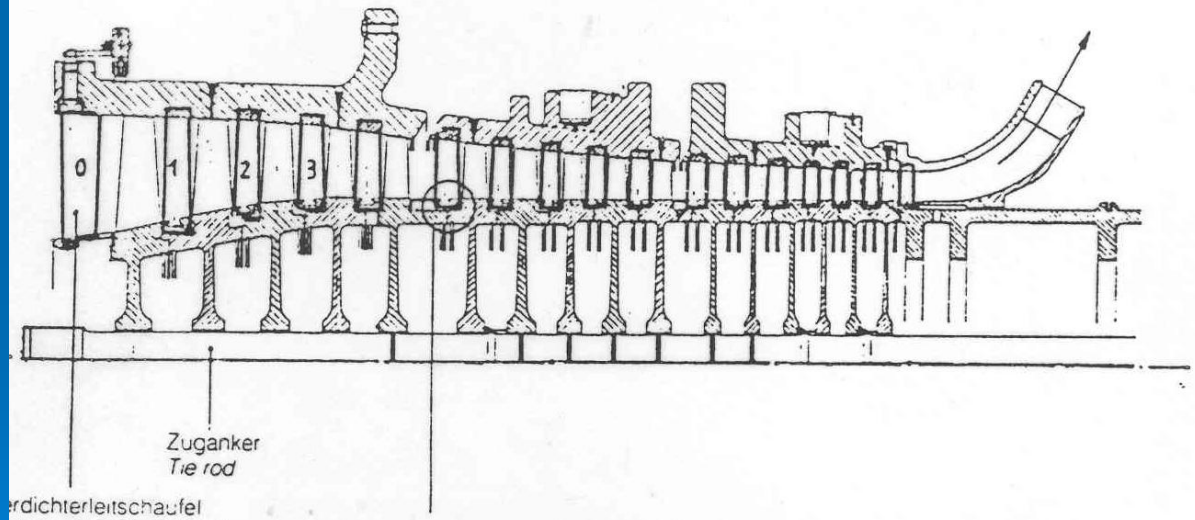
Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Verfahren *Test method*	Vorschrift *Test specification*
1	säubern - entfetten *clean - degrease*	Schaufelblatt - alle Stufen (im eingebauten Zustand) *Air foil - all stages (blades installed)*	SK *VT, MT*	TWP 1003 *TWP 1003*
2	Belag entfernen (Stahlwolle)** *remove deposits (steel wool)***	Verhakung für Innenring (im eingebauten Zustand) * *Hook for inner ring (hooks installed) **	US *UT*	TWP 1017 *TWP 1017*

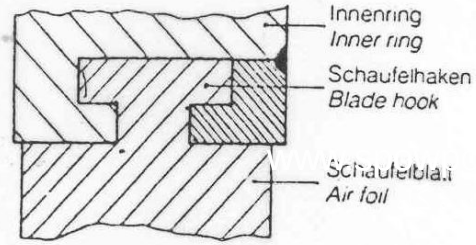
* Prüfung von jeweils 2 Verhakungen oberhalb und unterhalb der Teilfläche links und rechts (8 Schaufeln pro Leitschaufelkranz)

* *Testing of both hooks above and under the joint plane left and right (8 blades for each Compressor stator ring)*

** nicht an beschichteten Schaufeln

** *not on coated blades*

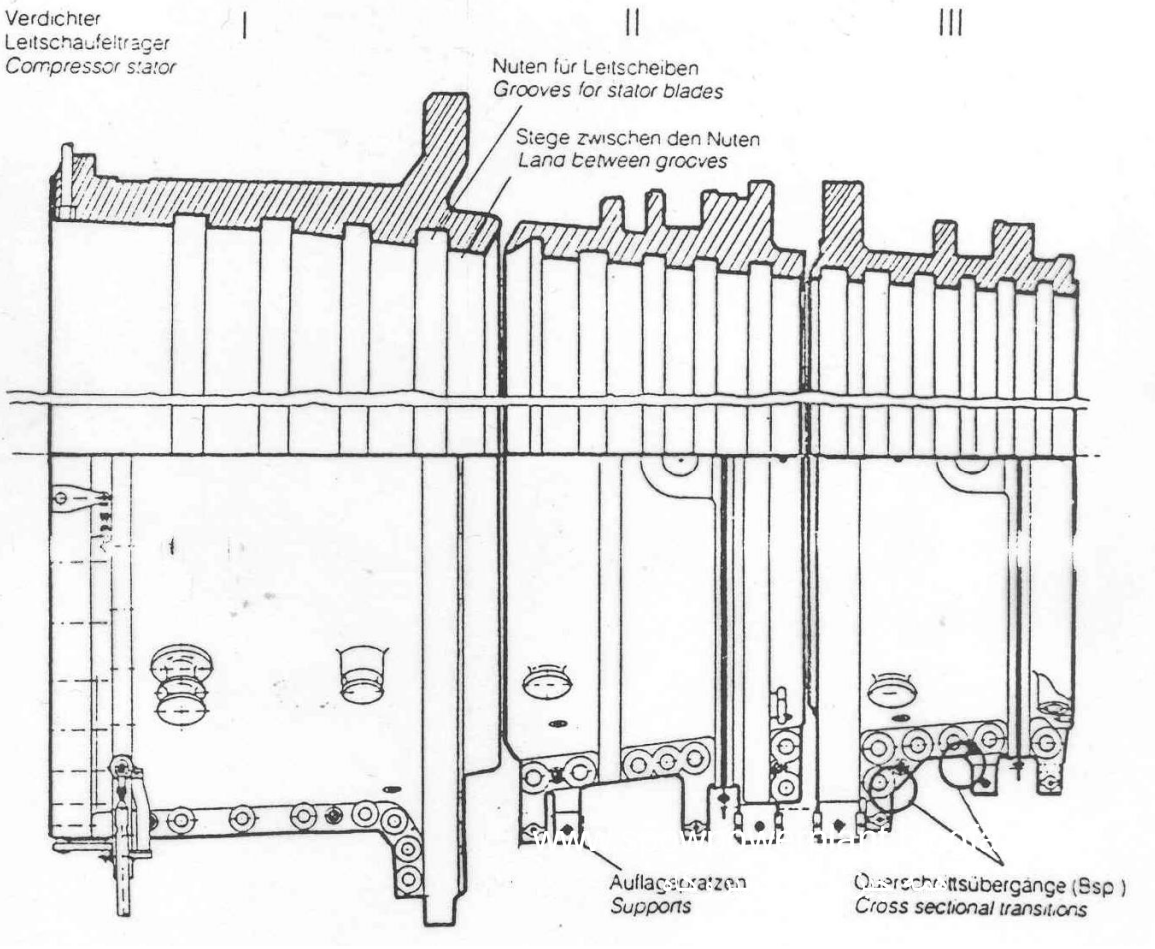




1	entfetten / ggf. beschleifen *degrease / grind. if reqd.*	Stege zwischen den Nuten** *Land between grooves***	SK *VT* MT*	TWP 1017 * *TWP 1017 **
2	entfetten *degrease*	Auflagepratzen *Supports*	SK *VT* MT*	
3	entfetten *degrease*	Querschnittsübergänge *Cross sectional transitions*	SK *VT* MT*	

* im Fall von Anstrefsc...
* *important if rubbing mark... are detected*

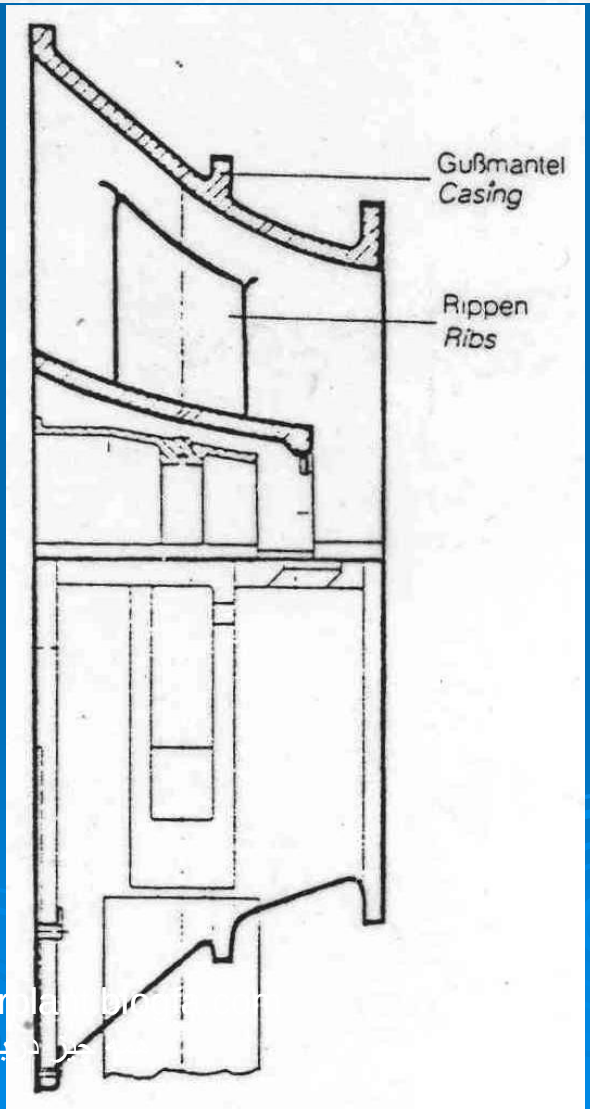
** soweit zugänglich
** *as far as accessible*



Compressor Stator *I,II,III*

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	entfetten *degrease*	Übergänge Rippen-Gußmantel *Transitions struts / inner- and outer shell*	SK *VT & MT*	

Compressor intake casing



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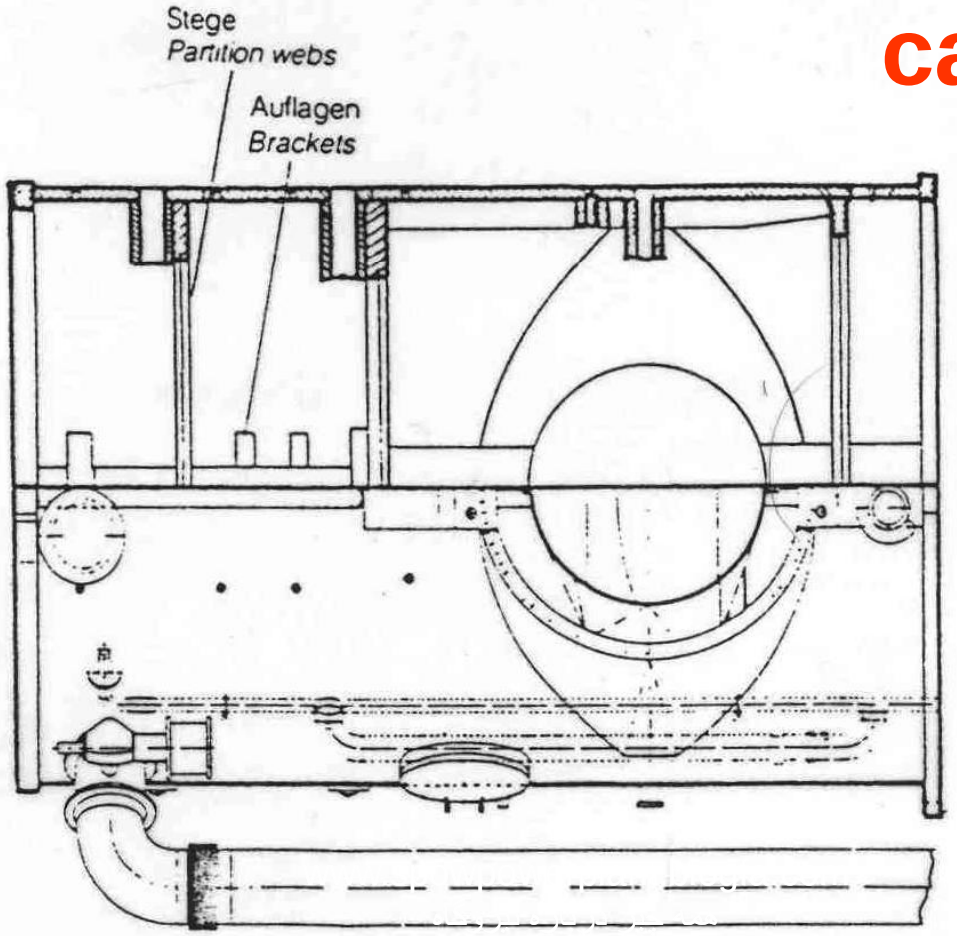
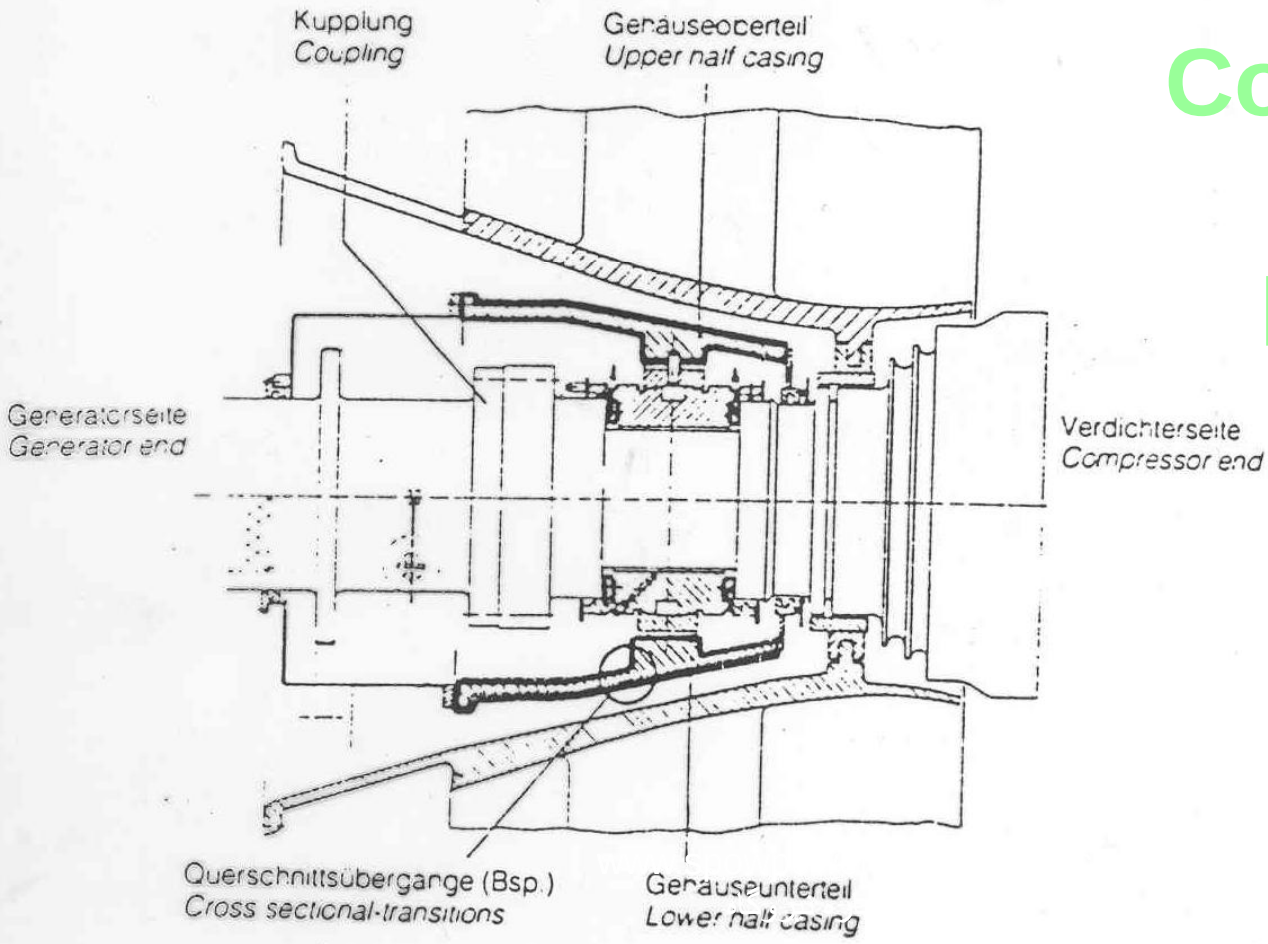
Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Verfahren *Test method*	Vorschrift *Test specification*
1	entfetten / ggf. beschleifen *degrease / grind, if reqd.*	Schweißnähte an Stegen und Teilfugenflansch *Welds on partition webs and joint flange*	SK *VT • MT*	
2	entfetten / ggf. beschleifen *degrease / grind, if reqd.*	Auflagen für Leitschaufelträger *Brackets for stator blade carrier*	SK *VT • MT*	

Center casing



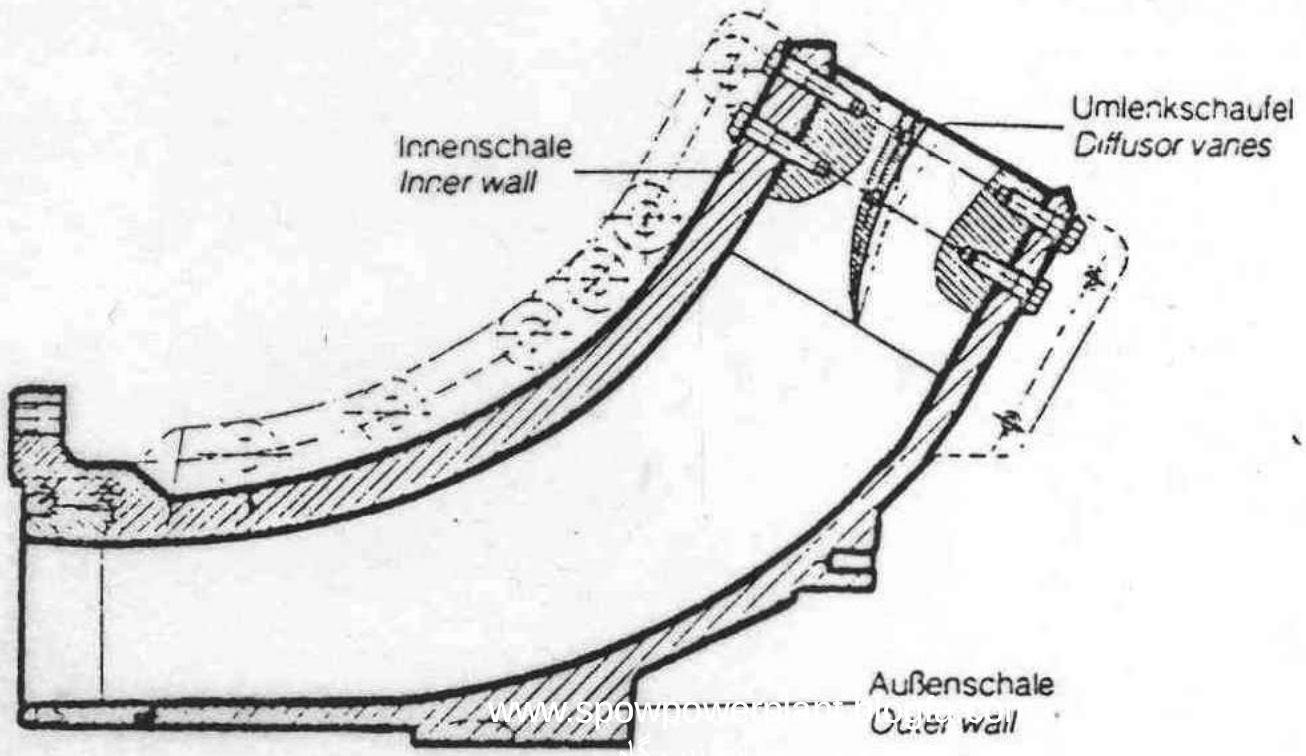
Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	entfetten / ggf. beschleifen *degrease / grind. if reqd.*	Querschnittsübergänge 100 % *Cross sectional transitions 100%*	SK *VT & MT*	



Compressor bearing housing

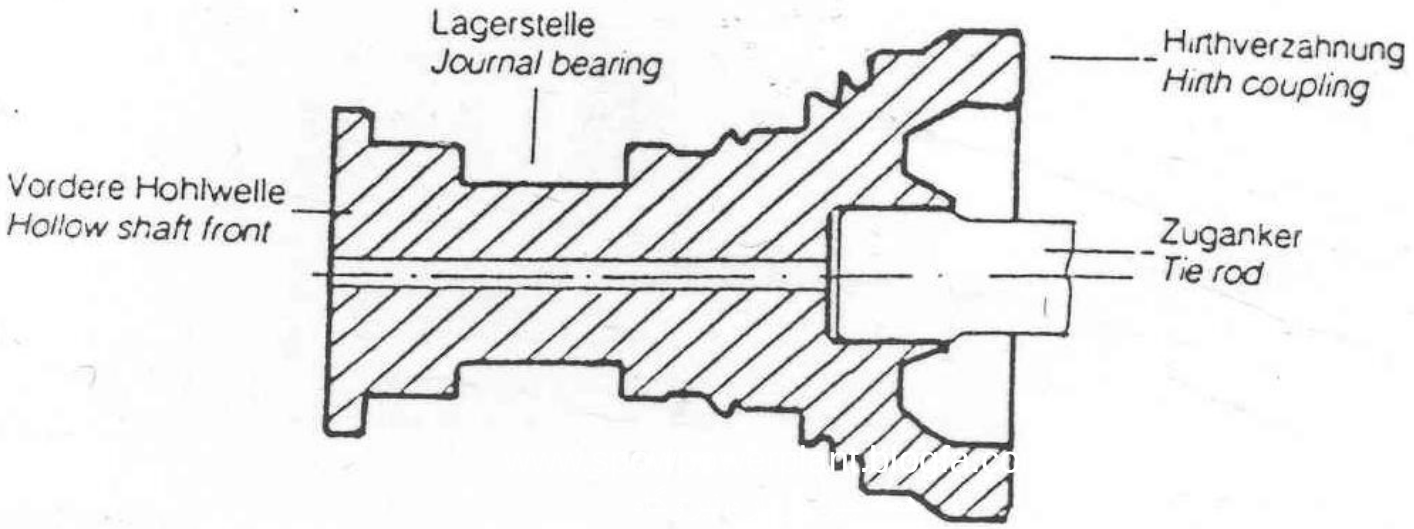
Compressor exhaust diffuser

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Verfahren *Test method*	Vorschrift *Test specification*
1	entfetten / ggf. schleifen *degrease / grind, if reqd.*	gesamte Oberfläche (soweit zugänglich) *total surface (as fare as accessible)*	SK *VT* PT	
2	entfetten *degrease*	Umlenkschaufeln *Diffusor vanes*	SK *VT* PT	

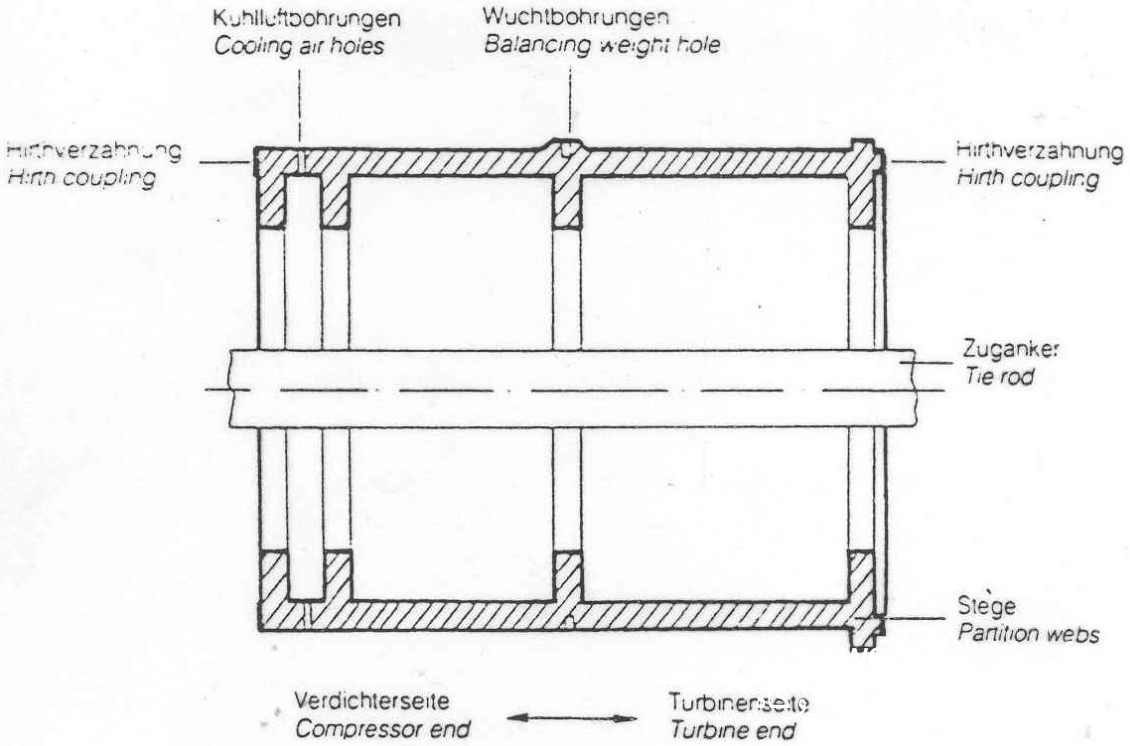


Front Hollow Shaft

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	entfetten *degrease*	Lagerstelle 100% *Journal bearing 100%*	MP *MT*	TWP 1017 *TWP 1017*
2	Belag entfernen (Drahtbürste - Stahlwolle) *remove deposits (wire brush - Steel wool)*	Hirthverzahnung 100% *Hirth coupling 100%*	MP *MT*	TWP 1017 *TWP 1017*



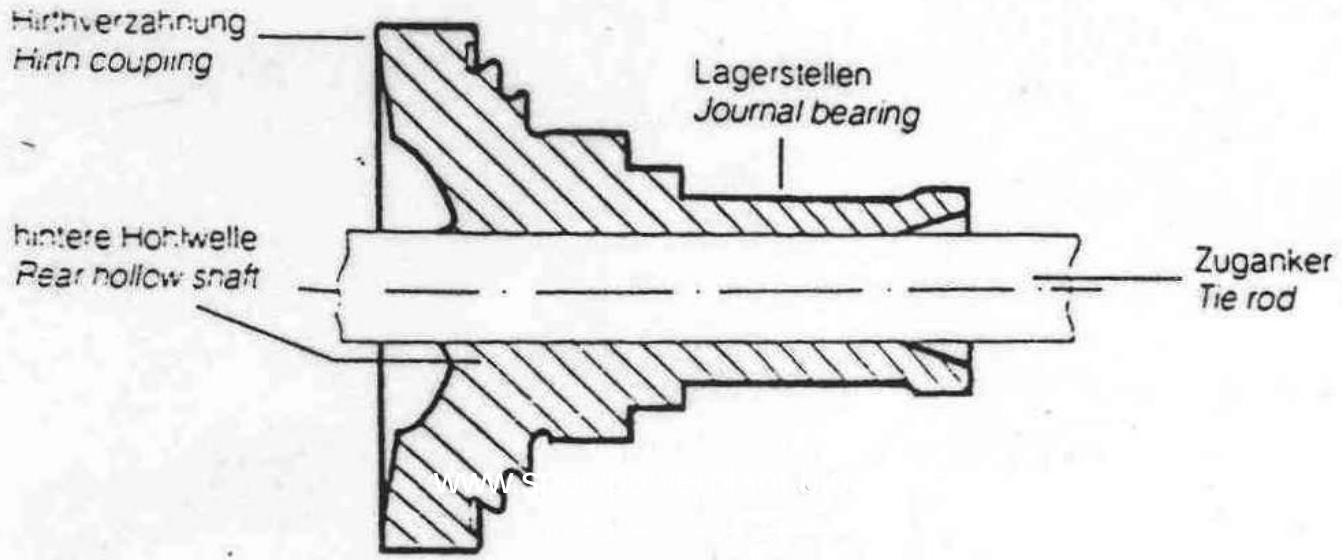
Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	*Test method*	*Test specification*
1	Belag entfernen (Stahlwolle / Drahtbürste) *remove deposits (steel wool / wire brush)*	Hirthverzahnung 100% *Hirth coupling 100%*	MP *MT*	TWP 1017 *TWP 1017*
2	Belag entfernen (Stahlwolle / Drahtbürste) *remove deposits (steel wool / wire brush)*	Kühlluftbohrungen 100% *Cooling air holes 100%*	FE *PT*	TWP 1019 *TWP 1019*
3	Belag entfernen (Stahlwolle / Drahtbürste) *remove deposits (steel wool / wire brush)*	Wuchtbohrungen 100% *Balancing weight holes 100%*	FE *PT*	TWP 1019 *TWP 1019*
4	Belag entfernen (Stahlwolle / Drahtbürste) *remove deposits (steel wool / wire brush)*	Wuchtbohrungen 100% *Balancing weight holes 100%*	WS *ET*	TWP 1148 *TWP 1148*
5	Belag entfernen (Stahlwolle / Drahtbürste) *remove deposits (steel wool / wire brush)*	Stege *Partition webs*	FE *PT*	TWP 1019 *TWP 1019*



Hollow Shaft (central)

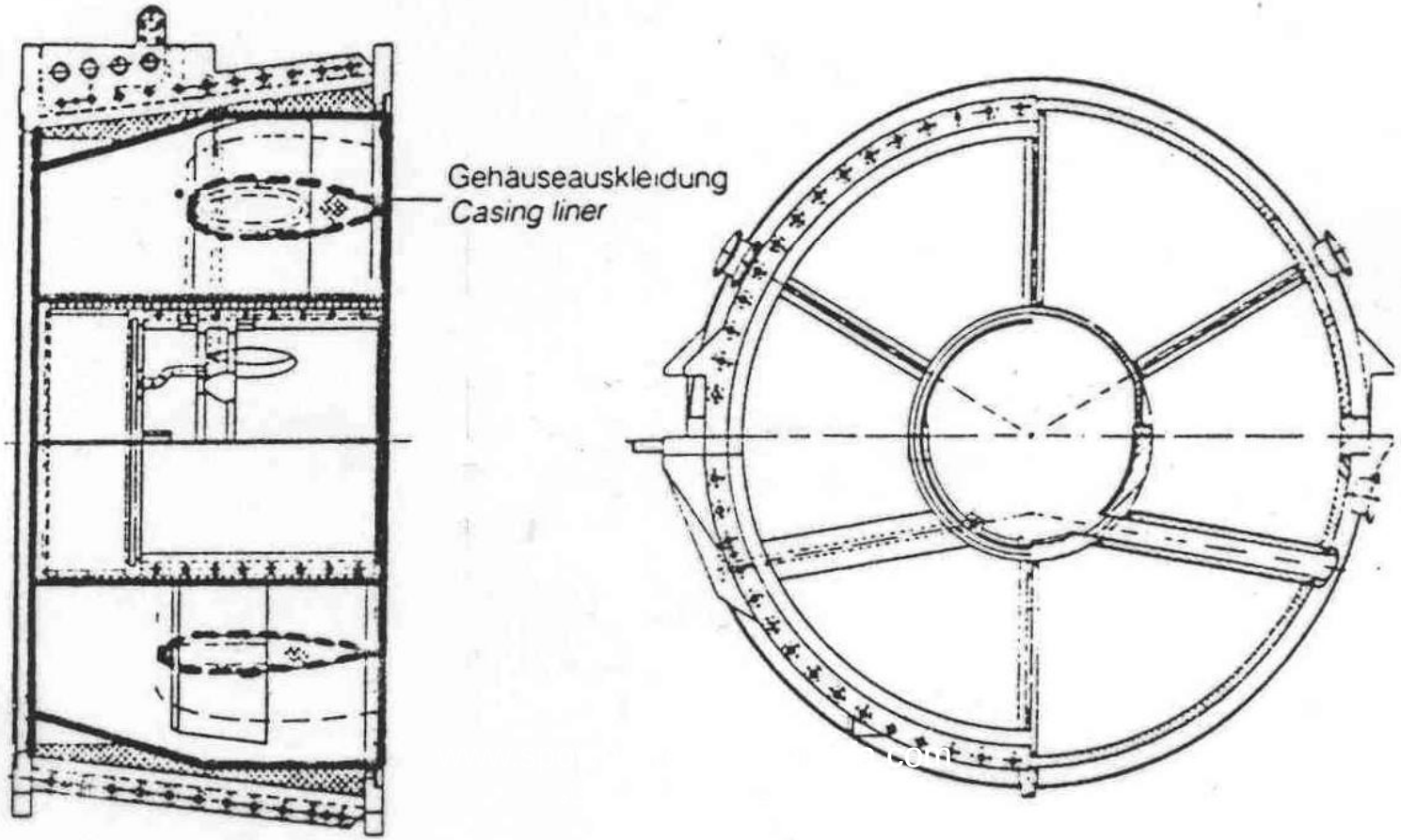
Hollow shaft rear

Prüf-Nr. / Test No.	Oberflächenvorbereitung / Surface preparation	Prüfbereich / Test area	Test method	Test specification
1	entfetten *degrease*	Lagerstelle 100% *Journal area 100%*	MP *MT*	TWP 1017 *TWP 1017*
2	Beläge entfernen (Stahlwolle und Drahtbürste) *remove deposits (steelwool and wire brush)*	Hirthverzahnung 100% *Hirth coupling 100%*	MP *MT*	TWP 1017 *TWP 1017*



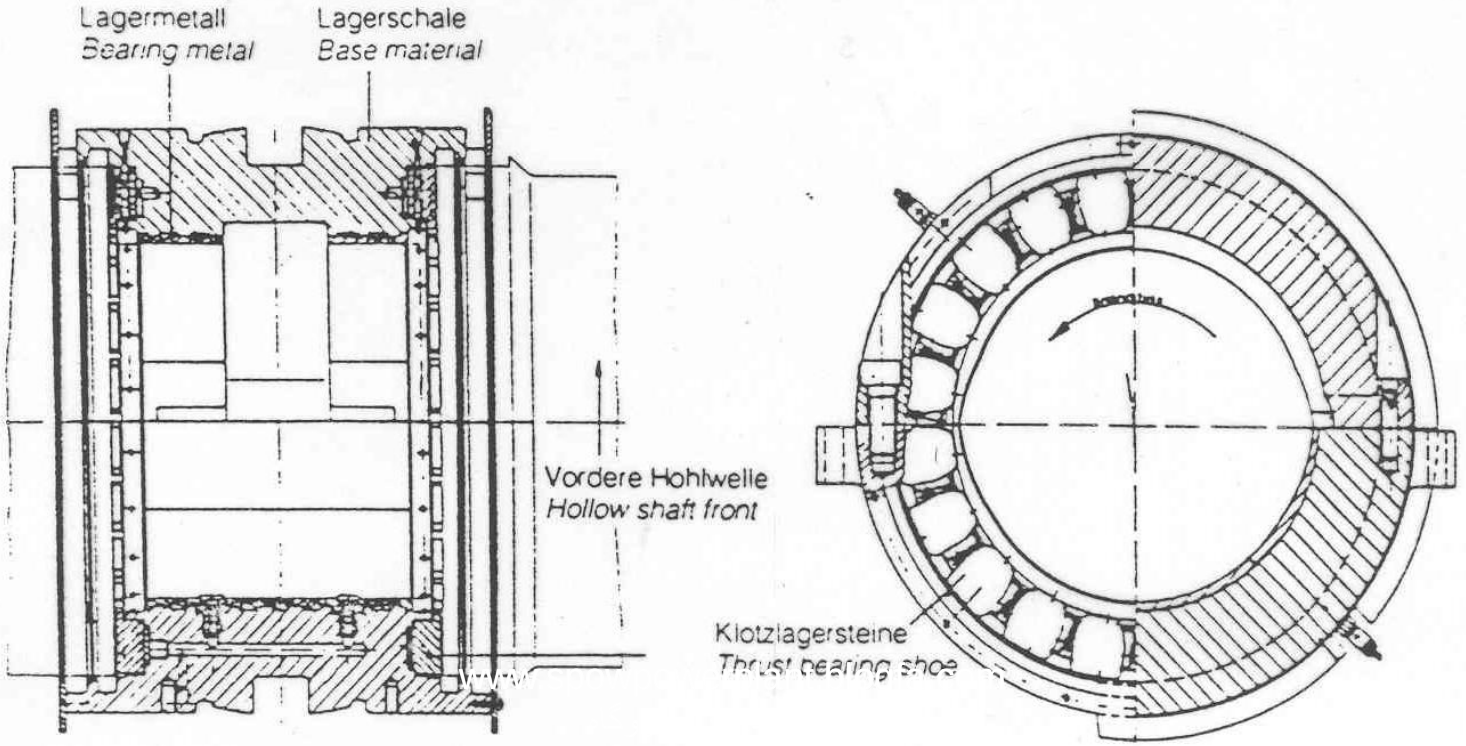
Turbine exhaust casing

Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	verfahren *Test method*	vorschrift *Test specificatio*
1	säubern mit Drahtbürste *clean with wire brush*	Gehäuseauskleidung: Schweißnähte 100% *Casing liner: welds 100%*	SK *VT, PT*	

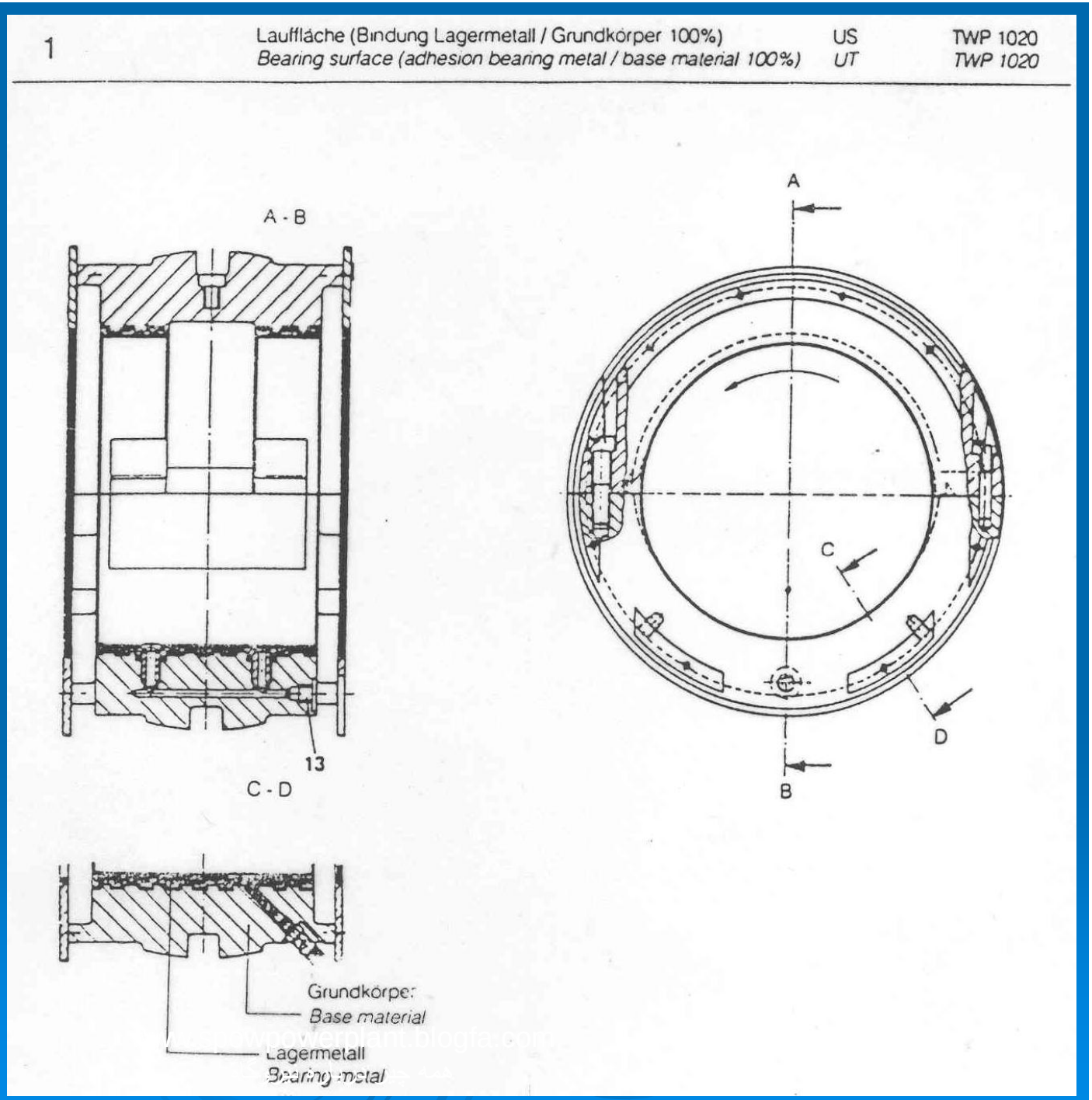


Compressor journal / thrust bearing

Prüf-Nr. *Test No.*	Oberflächen-vorbereitung *Surface preparation*	Prüfbereich *Test area*	Prüf-verfahren *Test method*	Prüf-vorschrift *Test specification*
1	—	Lauffläche (Bindung Lagermetall / Grundkörper 100%) *Bearing surface (adhesion bearing metal / base material 100%)*	US *UT*	TWP 1020 *TWP 1020*

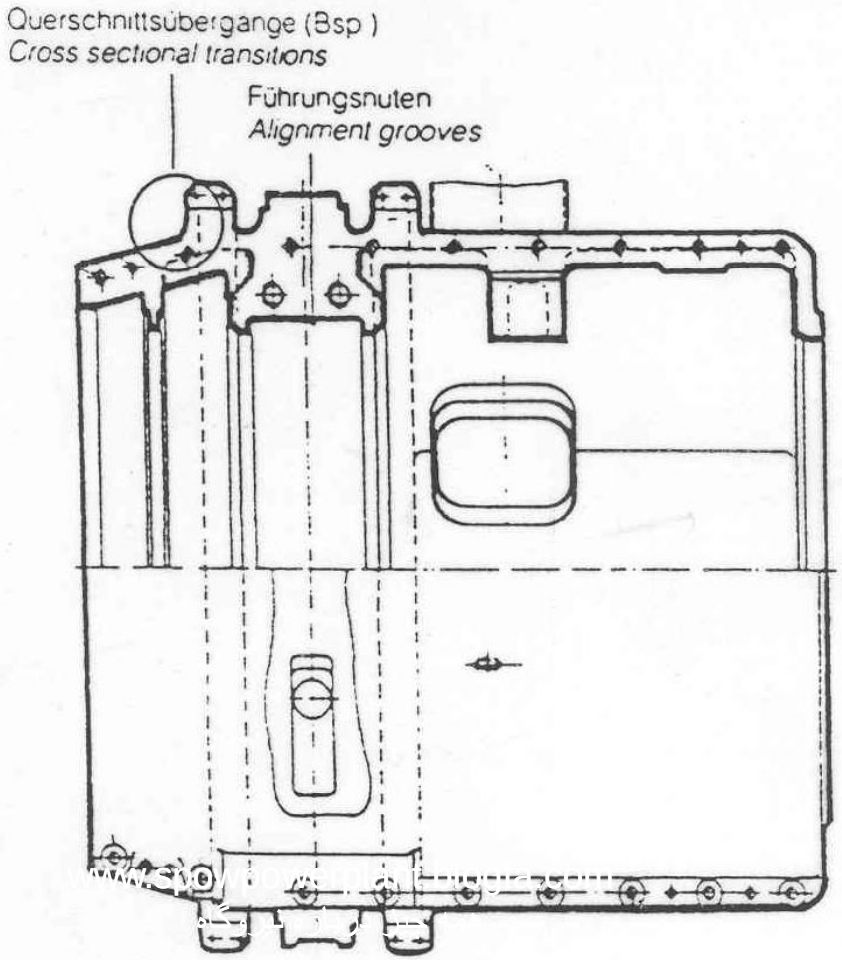


Rear-end journal bearing/ generator journal bearing



Rear-end bearing housing

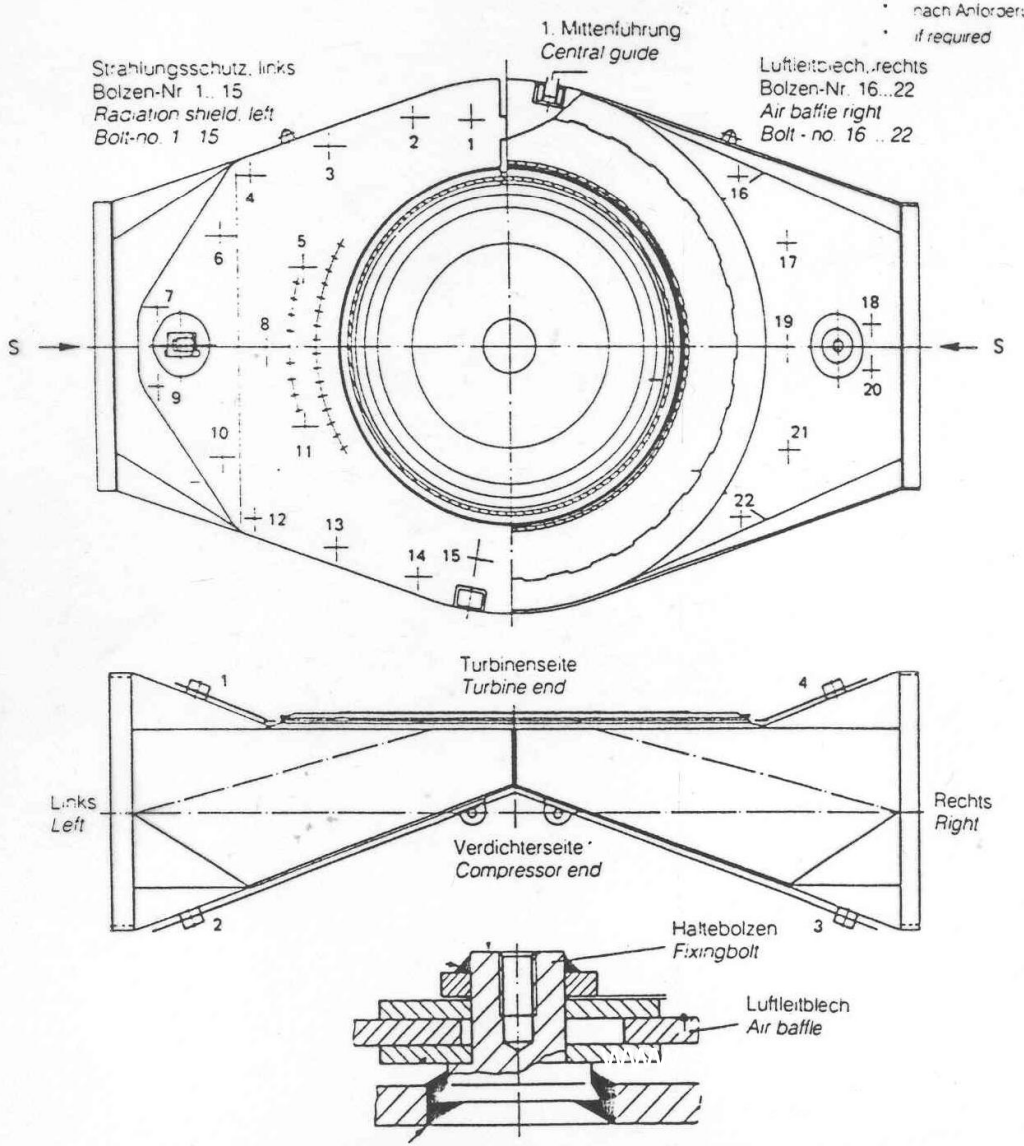
Prüf-Nr. *Test No.*	Oberflächenvorbereitung *Surface preparation*	Prüfbereich *Test area*	*Test method*	*Test specification*
1	entfetten / ggf beschleifen *degrease / grind. if reqd*	Querschnittsübergänge *Cross sectional transitions*	SK *VT, PT*	
2	entfetten *degrease*	Führungsnuten *Alignment grooves*	SK *VT, PT*	



Turbine inner casing

1	sandstrahlen *sand blasting*	Schweißnähte 100% *Welds 100%*	FE *PT*	TWP 1019 *TWP 1019*
2	sandstrahlen *sand blasting*	Gesamte Oberfläche 100% *Surface complete 100%*	SK *VT*	TWP 1019 *TWP 1019*
3	–	Wanddickenmessung *Wall thickness measurement*	US * *UT*	

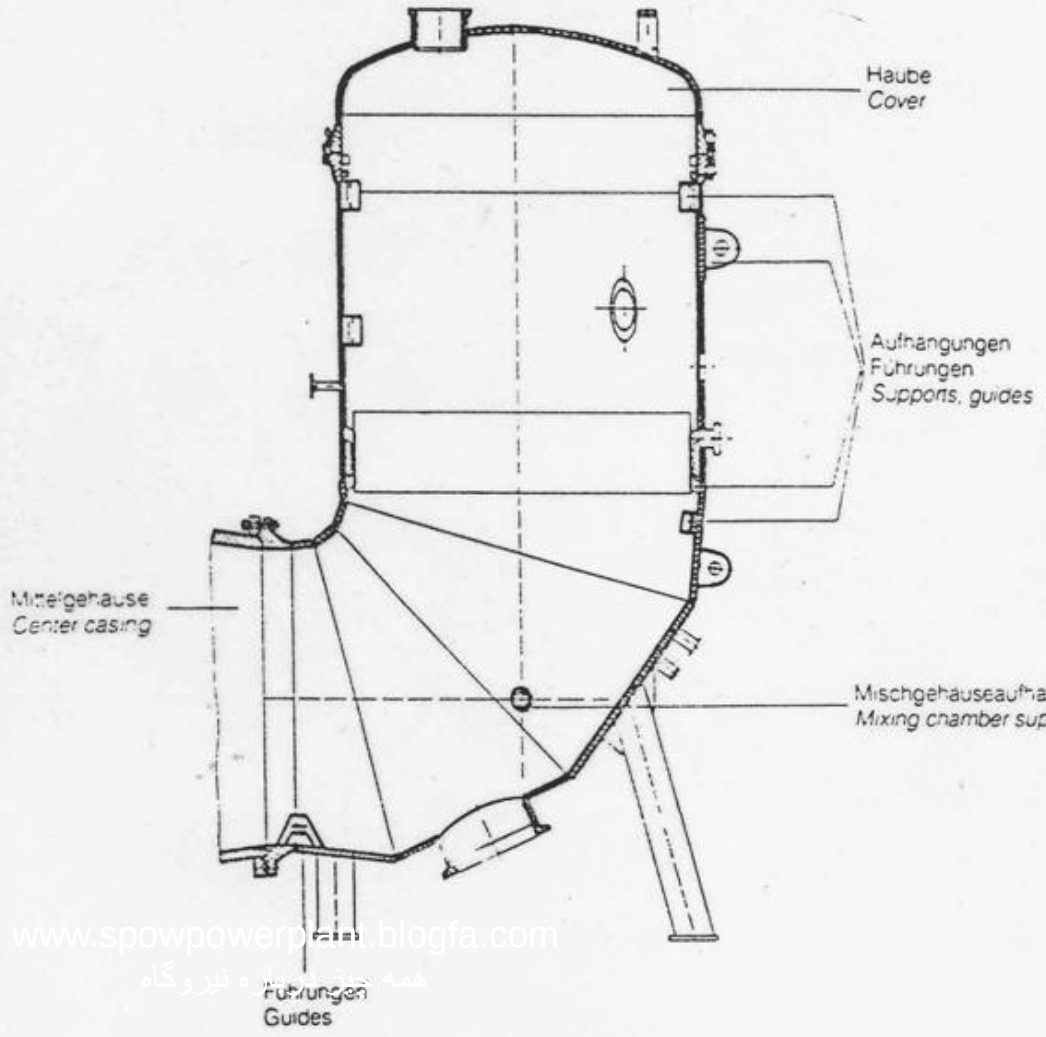
* nach Anforderung (z B TM)
* *if required*



Combustion chamber casing

1	entfetten * *degrease* *	Aufhangungen und Führungen für Innenteile des Druckmantels *Supports and guides for combustion chamber*	SK *VT, PT*
2	entfetten * *degrease* *	Schweißnähte *Welds*	SK *VT, PT*

* ggf. beschleifen; abhängig vom Belag bzw. Verwendungszweck
* *grind, if reqd (according to deposits)*



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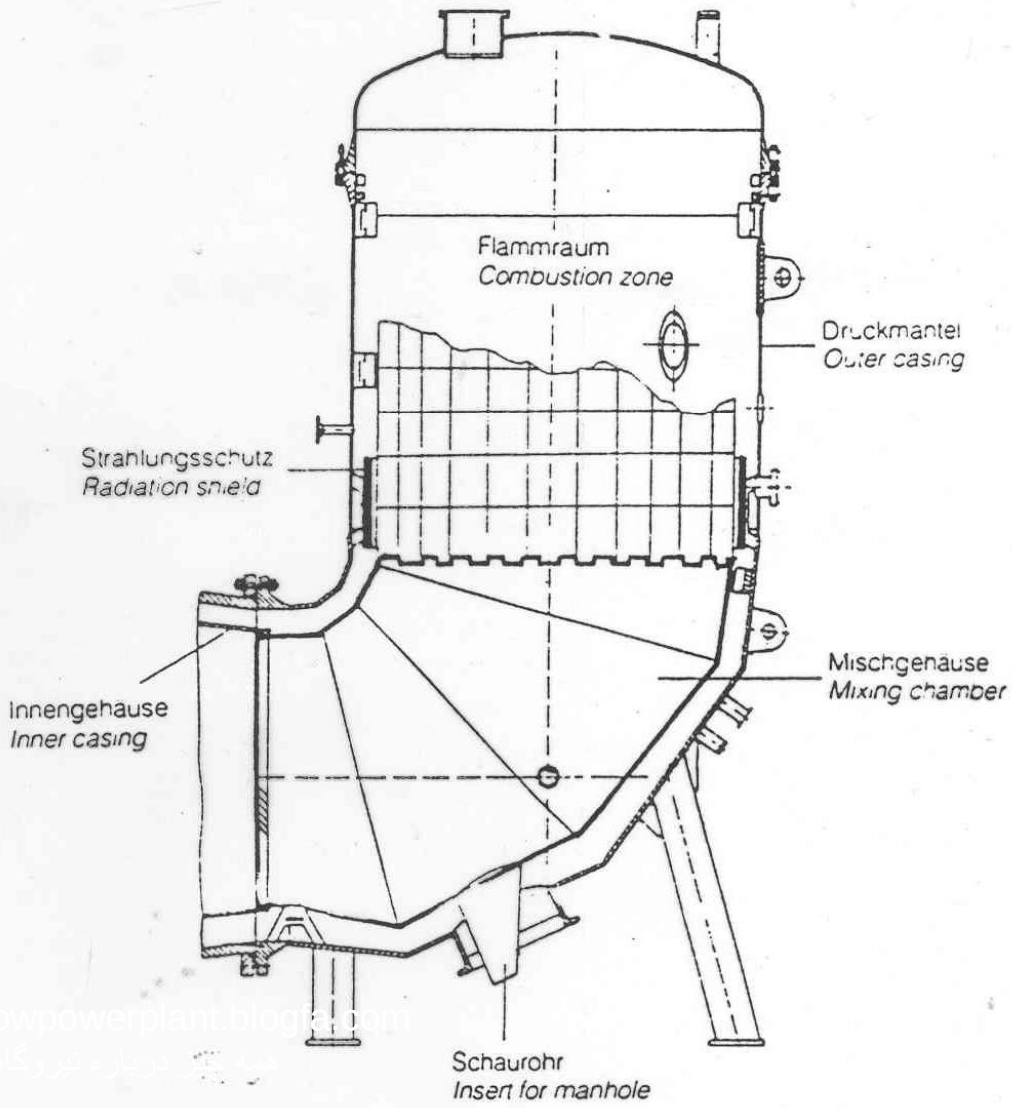
Radiation shield in combustion chamber/ mixing chamber

1	entfetten / ggf. beschleifen *degrease / grind, if reqd.*	Schweißnähte 100% *Welds 100%*	SK $VT_* PT$
2	entfetten / ggf. beschleifen *degrease / grind, if reqd.*	Übergänge zum Innengehäuse und Flammrohr *Transitions to inner casing and flame tube*	SK $VT_* PT$



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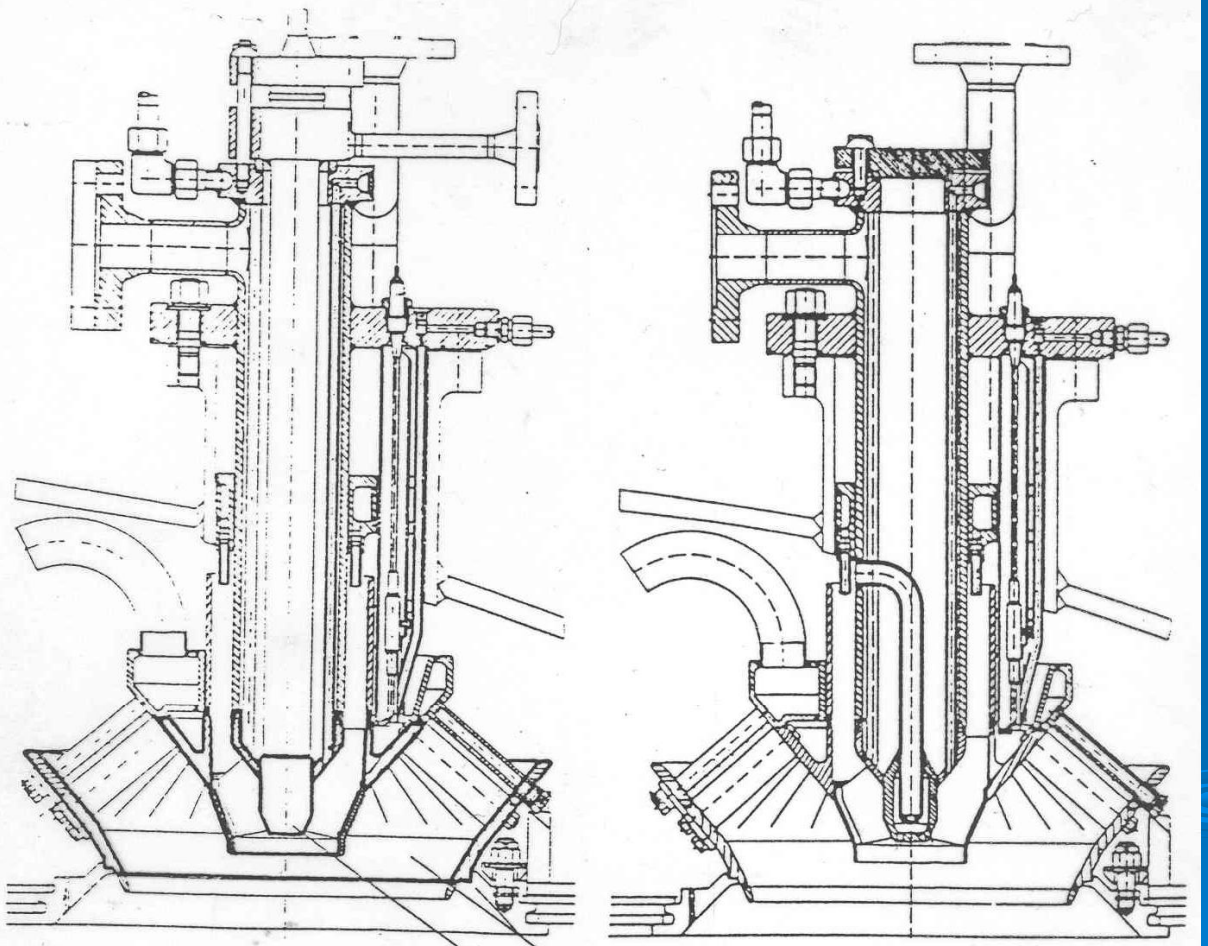
Dual-fuel burner

1	entfetten *degrease*	Düsenkopf (konische Flächen mit Austrittsöffnung) *Nozzle tip (tapered faces with outlet openings)*	SK *VT*
2	entfetten *degrease*	Luftführung *Air baffle*	SK *VT*



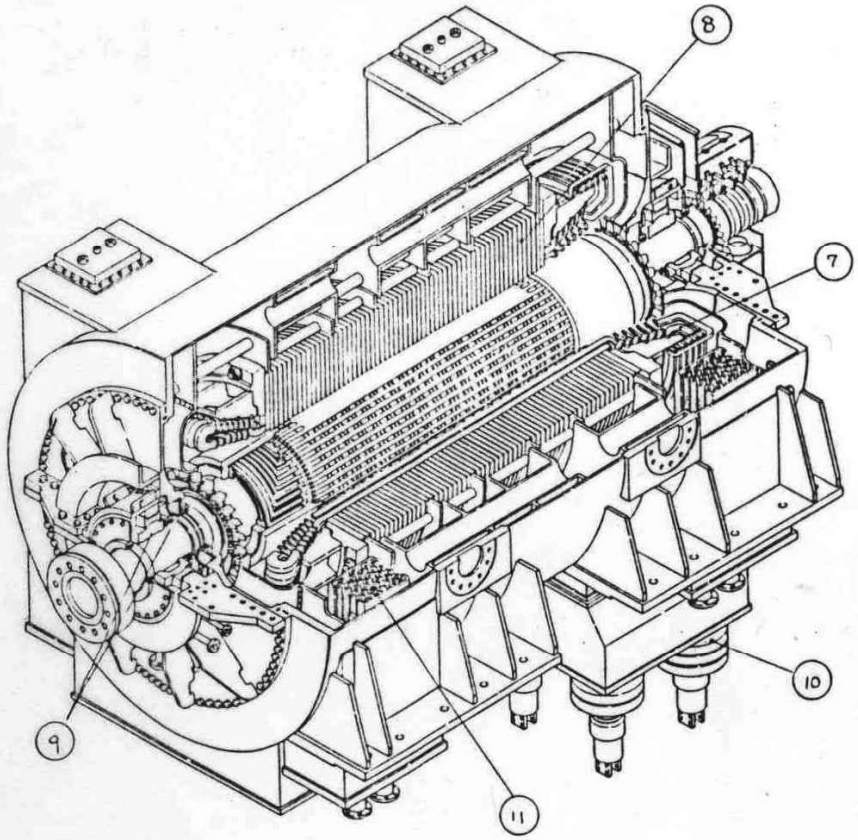
Brennkombination für Mischbetrieb oder Einzelbrennstoff
Burner combination for dual - or single fuel

Luftführung (Schweißnähte)
Air baffle (welds)

Düsenkopf (konische Flächen mit Austrittsöffnungen)
Nozzle tip (tapered faces with outlet openings)

Brennerkombination für Einzelbrennstoff Erdgas
Burner combination for single - fuel (natural gas)

RESIDUAL LIFE EVALUATION AND LIFE EXTENSION OF GENERATOR STATOR



(Explanation on symbols) UT : Ultrasonic flaw test
PT : Penetrant inspection VI : Visual inspection
MT : Magnetic particle flaw test HT : Hardness measurement
DI : Dimension inspection

RESIDUAL LIFE EVALUATION ITEMS

Name of Part		Life Control Part	Maintenance Control Item	Checking Method	Cause of Deterioration	Preventive Maintenance Method
Stator	⑦	Stator coil	Insulation deterioration Looseness of wedge and fixed part Insulation surface conditions	VI Insulation diagnosis	Load variation Temperature accumulation Fault Vibration	·Residual life evaluation of insulation ·Update of insulation
	⑧	Stator core	Core varnish (deterioration) and looseness	VI Loop heat test	Operation time	·Residual life evaluation ·Partial repair
Bearing and Seal ring	⑨	Slide surface	Wear	DI VI	Start and stop Operation time	·Residual life evaluation ·Corrective machining or update
High Voltage Bushing	⑩	Cemeting Parts	Crack and Hydrogen gas leakage	VI PT	Heat Cycle	· Residual life evaluation · Update of cooler
Hydrogen Cooler	⑪	Tubes	Tube thickness decrease	VI	Erosion Corrosion	· Residual life evaluation · Update of bushing

LIFE EXTENSION ITEMS

Name of part		Part	Life extension method
Stator	⑦	Stator coil	Rewinding with epoxy resin insulation system
	⑧	Stator core	Partial repair and revarnish
Bearing and sealing	⑨	Bearing Seal ring	Rebabbitt metal of bearing Replacement of seal ring and spring
High Voltage Bushing	⑩	Bushing	Replacement of bushing
Hydrogen Cooler		Cooler	Replacement of cooler

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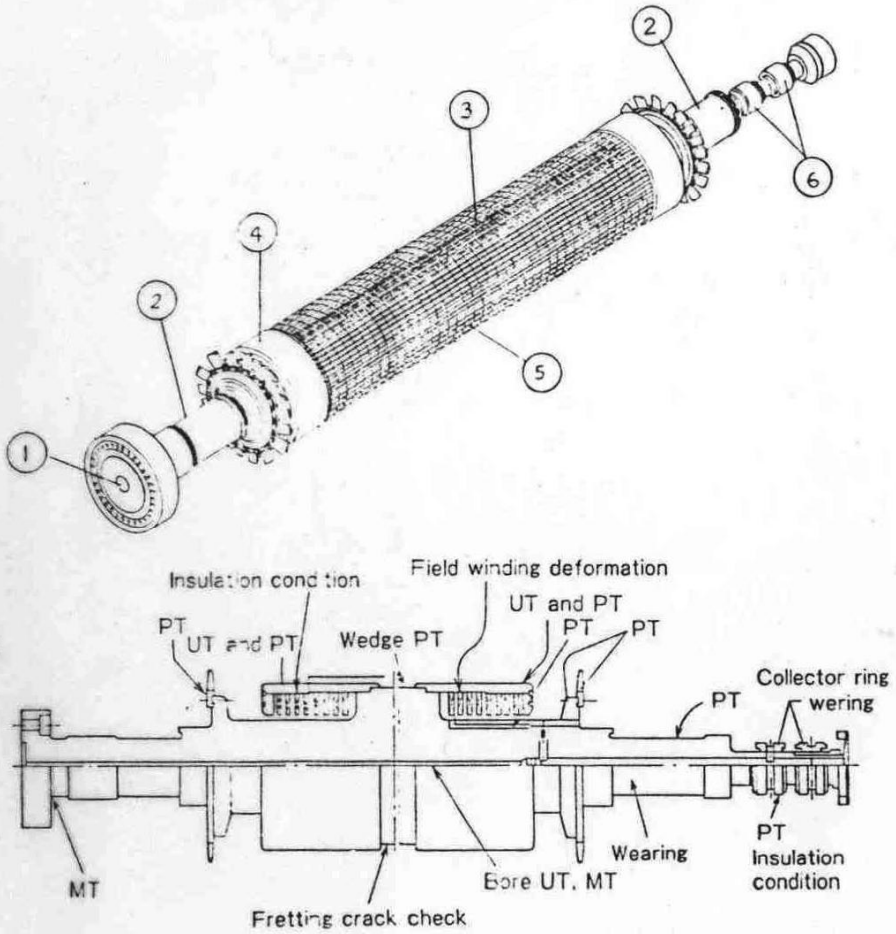
RESIDUAL LIFE EVALUATION AND LIFE EXTENSION OF GENERATOR ROTOR



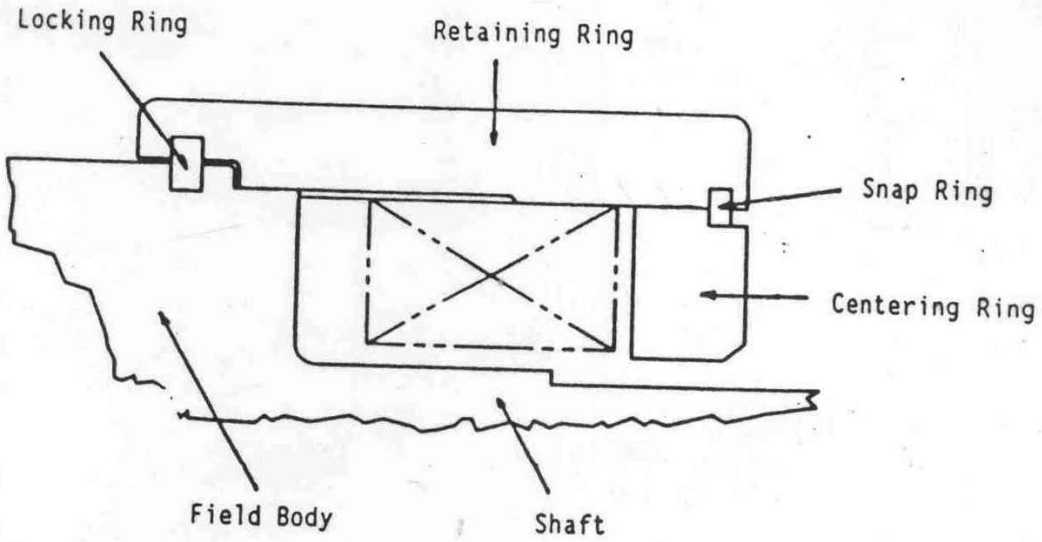
(Explanation on symbols) UT : Ultrasonic flaw test
PT : Penetrant inspection VI : Visual inspection
MT : Magnetic particle flaw test HT : Hardness measurement
DI : Dimension inspection

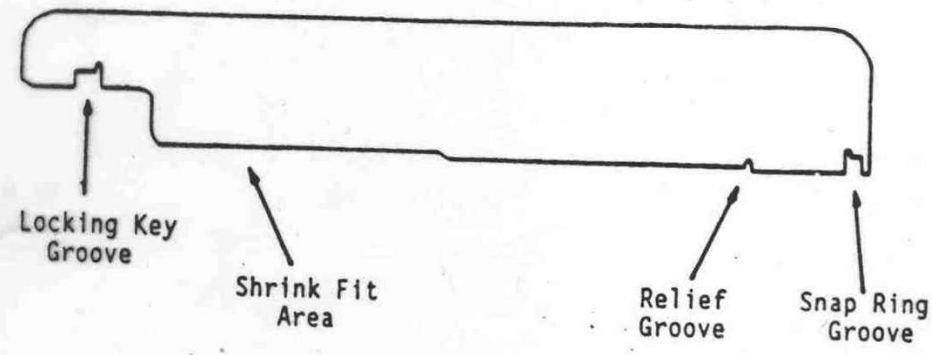
RESIDUAL LIFE EVALUATION ITEMS

Name of Part		Life Control Part	Maintenance Control Item	Checking Method	Cause of Deterioration	Preventive Maintenance Method
Rotor	①	Center bore of shaft	Low cycle fatigue (presence and development of defect or crack)	UT MT VI	Start and stop	· Residual life evaluation Crack removal
	②	Shaft journal part	Torsion fatigue (presence of crack)	MT PT	System fault short circuit fault Excessive Vibration	· Grasping of accumulated life consumption
	③	Rotor wedge	Fatigue and creep (presence of crack)	PT HT	Start and stop Temperature accumulation	·Residual life evaluation wedge ·replacement and form improvement
	④	Retaining ring	Stress Corrosion crack	PT UT	Moisture	· Crack removal · Residual life evaluation
	⑤	Coil and insulation	Insulation deterioration	VI	Start and stop Operation time	· Residual life evaluation of insulation · Update of insulation
			Top turn breakage	VI	Start and stop Operation time	· Top turn modification
	⑥	Collector ring	Wear of brush slide surface	DI HT	Operation time	·Residual life evaluation corrective machining or update

LIFE EXTENSION ITEMS

Name of part		Part	Life extension method
Rotor	③	Rotor wedge	Replacement and form improvement
	④	Retaining ring	In case of non magnetic steel, replacement of retaining ring with new material 18Mn18Cr
	⑤	Coil and insulation	Rewinding with new material
	⑥	Collector ring	Machining or replacement



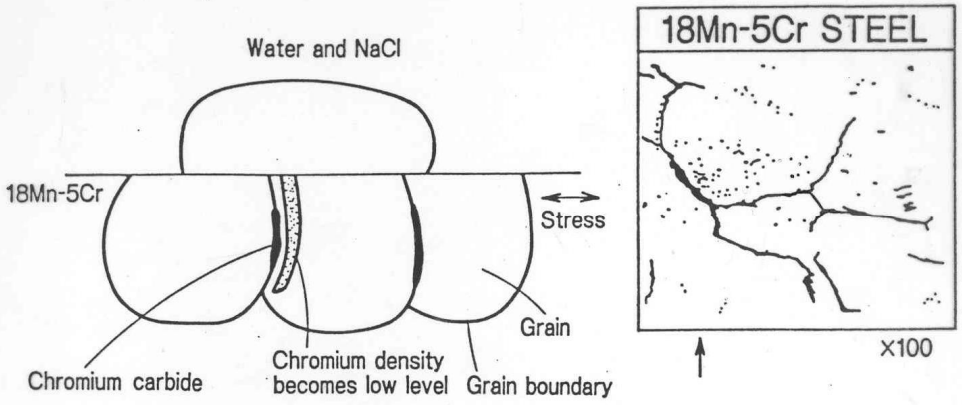


Critical Inspection Areas

Figure 2

Typical Body-Mounted Retaining Ring Installation and Critical Inspection Areas

MECHANISM OF STRESS CORROSION CRACKING FOR NON MAGNETIC RETAINING RING



(1) 18Mn-5Cr is non magnetic steel.

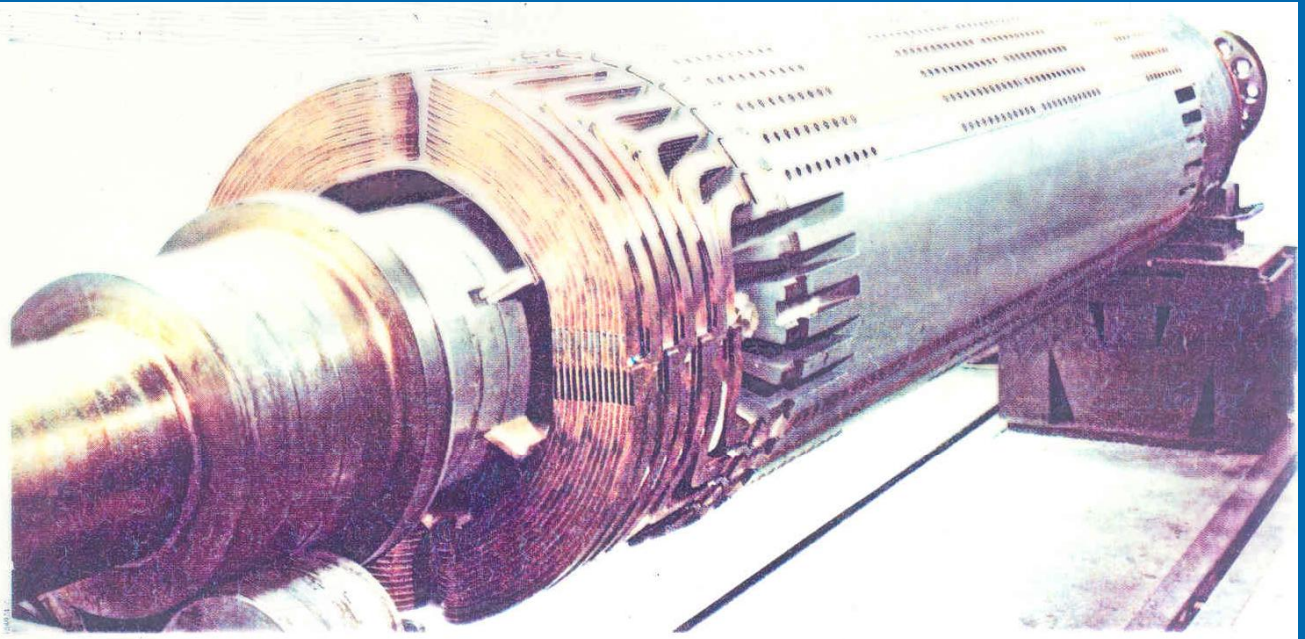
(2) To keep austenite steel, the solution treatment is necessary from 1050℃ with water quench.

(3) In this case, Cr (chromium) gathers at the grain boundary, then it becomes chromium carbide. Therefore the chromium density near the grain boundary becomes low level rather than other part.

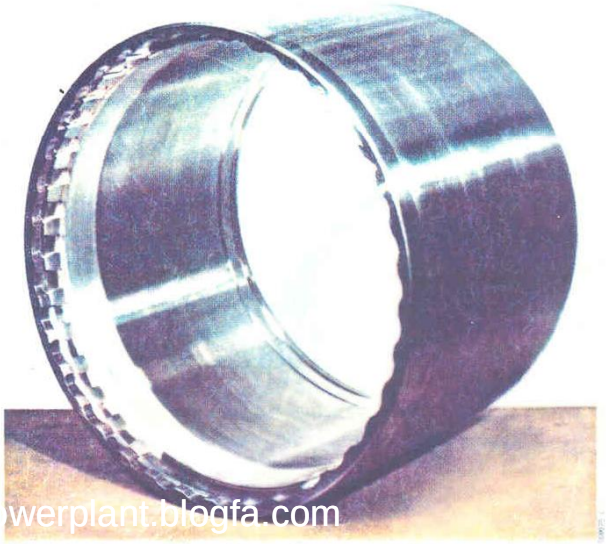
(4) Chromium is anti-corrosive material, so the low level part of chromium density is corroded selectively.

(5) It is the reason that the stress corrosion cracking appears near the grain boundary as shown on the picture.

Abstract	Stress corrosion cracking of retaining ring occurs by water at the inner surface of retaining ring. Therefore we must care about the dewdrop at retaining ring during operation and overhaul inspection.



Rotor with field winding in place



Retaining ring for Type 16L, with bayonet fitting

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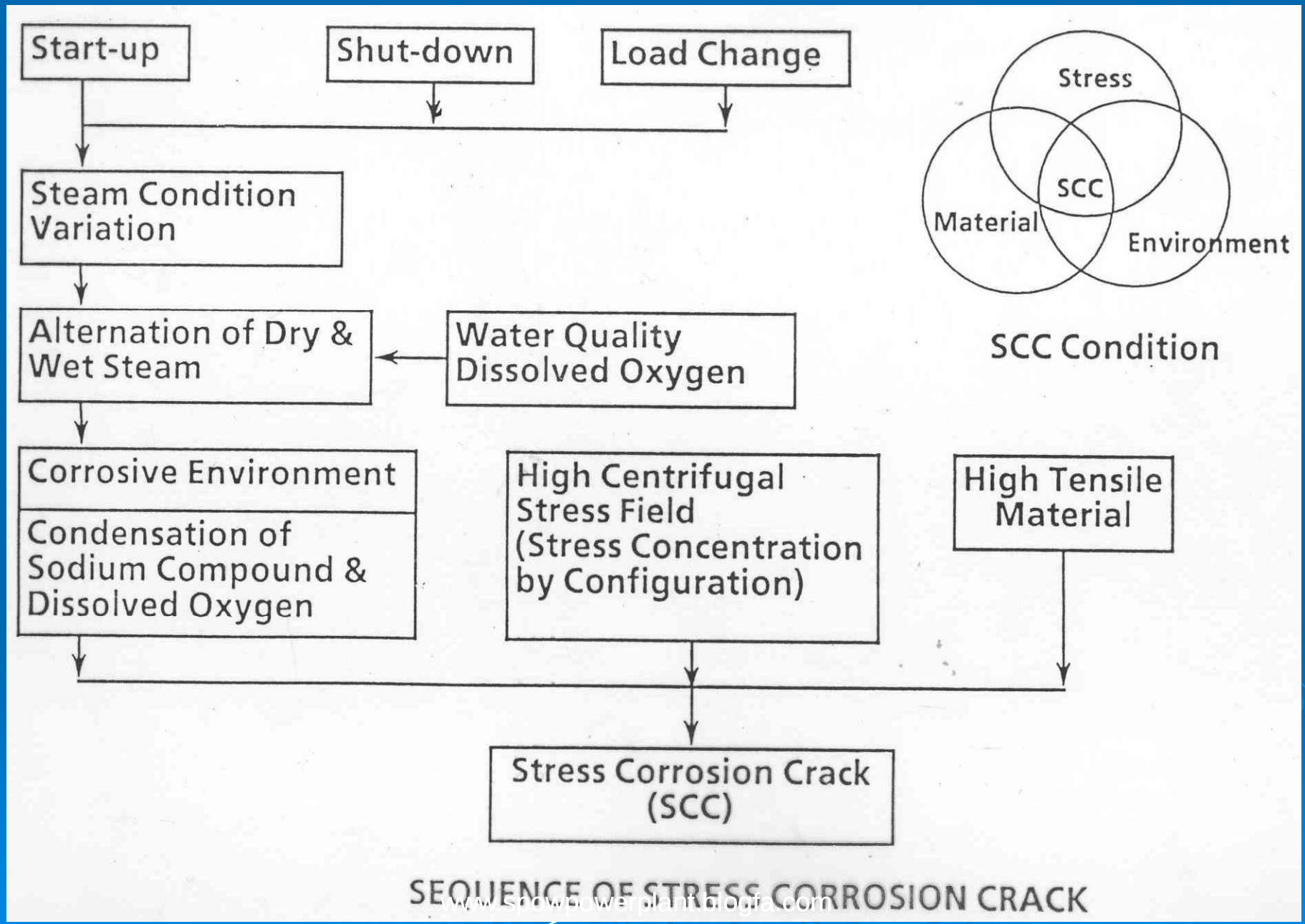
Tabelle 1
Entwicklung der nichtmagnetisierbaren Kappenringstähle zwischen 1901 und 1988 in unserem Hause.

Table 1
Development of non-magnetiz ble steel for retaining rings at c company between 1901 and 19.

Entwicklungs-jahr *Year*	KRUPP/VSG Stahlmarke *steel brand*	Chemische Zusammensetzung in Masse % *Chemical composition in % b.wt.*							
		C	Si	Mn	Ni	Cr	V	W	N
1901	BRUV	0,79	0,24	4,48	16,00	–	–	–	–
1910	MBR 22 C	0,27	0,20	0,44	21,80	3,00	–	–	–
1925	P 287*	–	–	6,00	8,50	10,25	–	–	–
1925	P 288*	–	–	6,00	8,50	3,50	–	1,50	–
1925	P 289*	–	–	6,00	6,50	10,25	–	0,80	–
1925	P 290*	–	–	7,50	7,50	4,25	–	–	–
1926	P 323*	0,56	0,18	8,22	10,10	4,15	–	–	–
1926	P 324*	0,57	0,13	11,10	4,19	4,39	–	–	–
1928	EFC 212 G	0,55	0,40	5,00	12,50	3,60	–	–	–
1928	EC 202 G	0,60	0,40	5,00	15,00	–	–	–	–
1934	EFC 284	0,20	0,40	6,00	10,00	11,50	–	–	–
1938	EFC 212 W	0,58	0,40	7,50	8,50	4,00	–	0,60	–
1939	CF 87212	0,48	0,40	17,50	–	3,00	–	–	–
1939	CF 6724	0,32	0,38	18,00	–	1,00	–	–	–
1954	P 750* (UKR)	0,53	0,80	18,00	–	4,50	0,10	–	0,10
1958	P 794*	0,60	0,25	15,00	–	15,00	2,00	–	–
1960	P 805*	0,52	0,40	20,00	–	14,00	1,20	–	–
1967	P 870*	0,65	0,75	19,50	1,50	6,20	0,10	–	0,14
1975	P 898*	0,55	0,40	20,00	1,00	6,00	–	–	0,10
1975	P 899*	0,50	0,50	18,00	0,40	4,65	0,55	–	0,10
1975	P 900*	<0,12	0,30	18,50	–	18,50	–	–	0,50
1981	P 900 N*	<0,12	1,00	18,50	<1,00	18,50	–	–	1,00

*Probequalitäten als Versuchsmarken vor der regelmäßigen Erschmelzung.

**Trial grades before regular production.*



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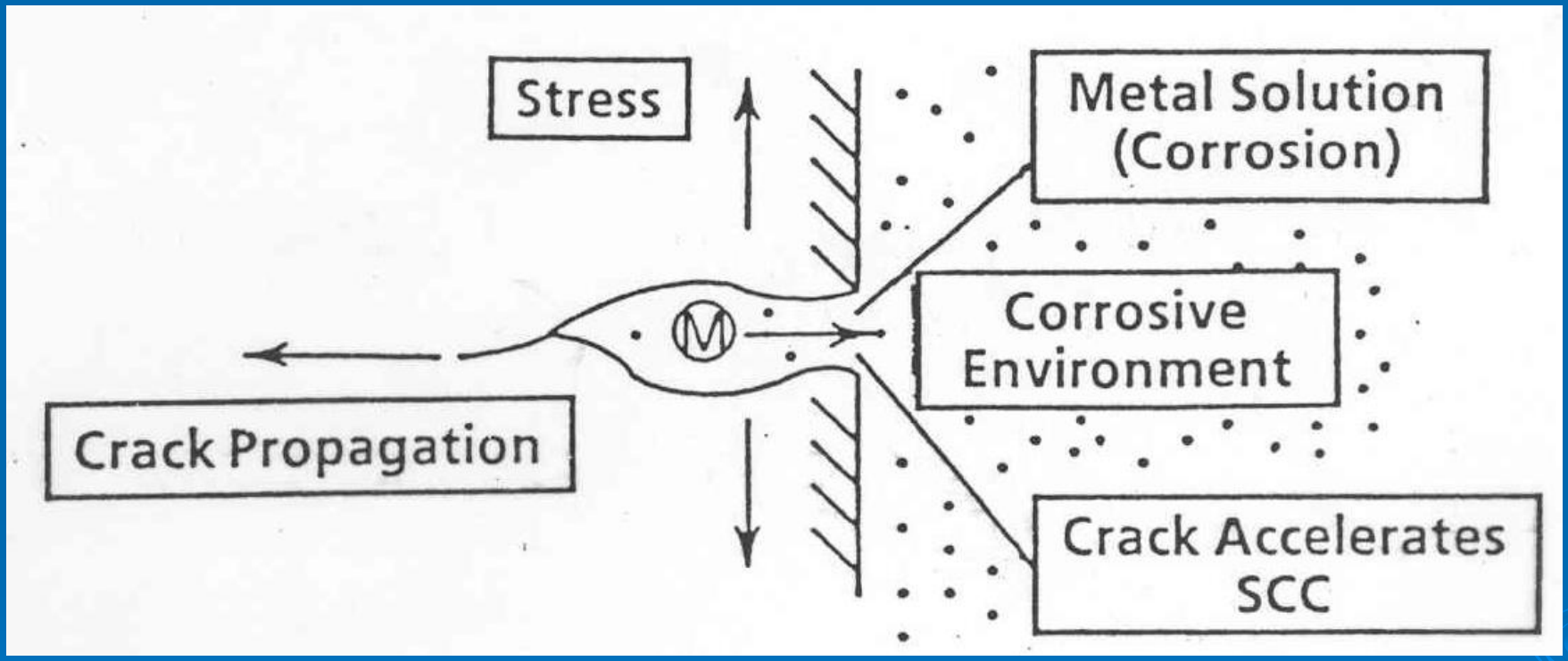
MECHANISM OF STRESS CORROSION CRACK



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RECOMMENDATION OF INSPECTION AND STORAGE

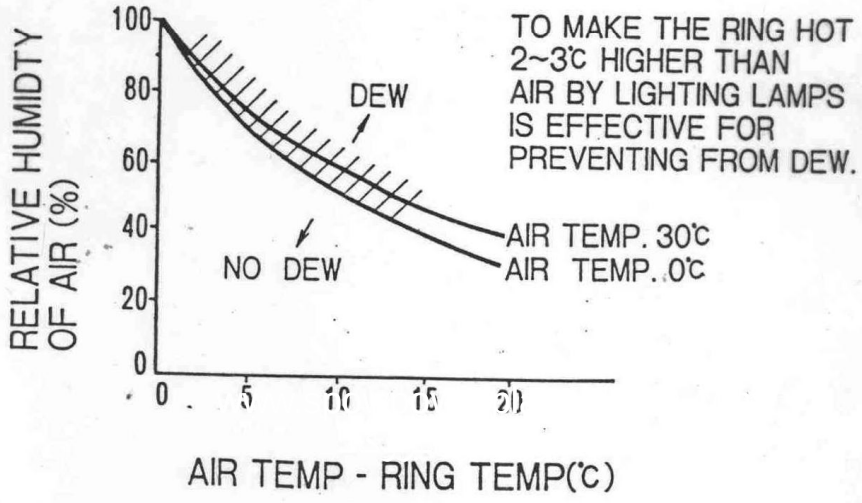
RECOMMENDED INSPECTION

NO.	ITEM	EXPLANATION
1	INSPECTION AFTER DISMANTLING ROTOR	ONE TIME PER FOUR YEARS (1) ULTRASONIC INSPECTION (2) VISUAL INSPECTION IF FLAW DETECTED, THE NEXT ITEM IS TO BE CARRIED OUT.
2	INSPECTION AFTER DIS-ASSEMBLY OF RING	ONE TIME PER EIGHT YEARS (1) LIQUID DYE PENETRANT INSPECTION (2) VISUAL INSPECTION (3) DIMENSION CHECK IF REQUIRED, SHRINK FITTING SURFACES ARE TO BE INSPECTED BY MICROSCOPE.

RECOMMENDED STORAGE

THE FOLLOWING TREATMENT IS RECOMMENDED NOT TO MAKE DEW ON THE ROTOR DURING YEARLY INSPECTION OR LONG STORAGE.

THE CONDITION OF DEW IS DESCRIBED IN THE NEXT FIGURE.



TO MAKE THE RING HOT 2~3℃ HIGHER THAN AIR BY LIGHTING LAMPS IS EFFECTIVE FOR PREVENTING FROM DEW.