
UNIVERSITI SAINS MALAYSIA

Peperiksaan Semester Pertama
Sidang Akademik 2003/2004

September/Oktober 2003

EBB 405E/3- Penyiasatan Kegagalan Dan Ujian Tak Musnah

Masa: 3 jam

Sila pastikan bahawa kertas peperiksaan ini mengandungi TIGA PULUH EMPAT muka surat yang bercetak sebelum anda memulakan peperiksaan.

Kertas soalan ini mengandungi TUJUH soalan. DUA soalan pada Bahagian A dan LIMA soalan pada Bahagian B.

Jawab **SEMUA** soalan (Wajib) pada Bahagian A dan **EMPAT** soalan pada Bahagian B.

Ceraikan BAHAGIAN A dan kepilkan bersama buku jawapan.

Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru.

Jawab semua soalan dalam bahasa Inggeris. Jika calon memilih untuk menjawab dalam bahasa Malaysia maksimum dua soalan dibenarkan.

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SECTION A

BAHAGIAN A

1. True and false (You may answer on the page and attach it with answer scripts).

- (1) Bleed out creates an indication that is smaller than the discontinuity.
- (2) Adhesives are added to the developer in order to disperse the particles in the water.
- (3) When applying a nonaqueous wet developer on the surface of the part, only a light fine mist is needed.
- (4) Developers help blot out the penetrant that has remained in any discontinuities and increase the dispersion of the penetrant laterally.
- (5) High drying temperatures increase the evaporation of the penetrant thus preventing the penetrant from coming in contact with the developer which results in an inability to detect discontinuities.
- (6) Surfactants and dispersants are used to help the nonaqueous wet developer coat the surface of the part evenly when it is sprayed.
- (7) It's important that the developer is not shaken before use and that the spray nozzle is not clogged.
- (8) A discontinuity detected on the surface of the part is more harmful than a discontinuity of the same size located below the surface of the part.
- (9) Small cracks may show a linear indication that could be intermittent.
- (10) All discontinuities are rejectable.

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- (11) One way to determine if an indication is relevant is to spray a small amount of solvent on the surface of the part and watch for repeated bleed-out.
- (12) The investigator does not care to record pertinent features on failed parts.
- (13) It is recommended to re-mate the fracture surfaces to see if they fit together.
- (14) A common procedure is to spray the fracture with a clear enamel or acrylic to create artifacts that would confuse or inhibit fracture interpretation.
- (15) Moisture created from the cleaning process or humidity can greatly affect the ability of the penetrant to float onto the surface of the part and produce capillary action.
- (16) Cleaning a part is performed in order to remove any contaminants that may compromise the inspection process.
- (17) Inorganic contaminants are materials such as rust, dirt, mineral deposits, plastic and salt.
- (18) Alkaline cleaners are detergents that remove certain types of organic contaminants. These include most oil based contaminants.
- (19) Ultrasonic cleaning can only remove organic contaminants.
- (20) It's important that the cleaning process should slightly etch the part.
- (21) Heavy scale or paint is not recommended when performing liquid penetrant testing.

- (22) Inorganic contaminants are materials such as oil, paint, varnish and lubricants.
- (23) The shape of the part will not create excess background masking.
- (24) Parts that require assembly can also produce non-relevant indications that require interpretation.
- (25) Over the life of black light, dust and dirt accumulate on the surface of the filter and reduce its sensitivity.
- (26) Magnesium crack blocks are the most common test block used to evaluate penetrant performance.
- (27) It is usually better to leave the black light turned on for an entire shift rather than turning it on and off throughout the shift.
- (28) A penetrant system performance test panel may be used to test the washability of penetrant.
- (29) System performance test panels will not become contaminated and require replacement.
- (30) Low pressure fluorescent bulbs are good for washing off the excess fluorescent penetrant and for the final inspection.
- (31) When the "TAM" panel is tested, the number of star cracks that can be identified is used to determine the fluorescence of the penetrant.
- (32) The best identification of discontinuities occurs when a minimum of 4 ft candles of white light or background light is present.
- (33) The transformer used with black lights will help regulate the line voltage variations.

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- (34) Ultraviolet light has a wavelength just below visible light.
- (35) The temperature of the housing and the filter can become very hot.
- (36) TAM panels have two distinct sides. The rough side is used to determine the washability of the penetrant.
- (37) Black light intensity will vary with line voltage.
- (38) Always operate a black light without the filter in place.
- (39) The minimum penetrant dwell time is based on the established procedures.
- (40) If the part under inspection is too large for the penetrant tank, the spraying method can be used.
- (41) A part may need to be rotated or redipped in order for the part to have complete coverage.
- (42) Hotter parts require a longer dwell time.
- (43) Once the penetrant has completely entered a discontinuity, a longer dwell time will not improve the results.
- (44) Penetrant bleed-out from a crack will look like a rounded indication.

(100 marks)

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BAHAGIAN A

1. *Betul dan Salah (Anda boleh menjawab pada kertas soalan dan kepilkan dengan skrip jawapan).*
 - (1) *Jujuhan keluar yang terhasil memperlihatkan keadaan yang lebih kecil daripada kecacatan sebenar.*
 - (2) *Perekat yang ditambah kepada bahan penyerlah bertujuan menyerakkan partikel-partikel di dalam air.*
 - (3) *Apabila bahan penyerlah basah nanoakuas digunakan pada sesuatu satah permukaan hanya kabus nipis yang diperlukan.*
 - (4) *Bahan penyerlah membantu mengeluarkan bahan penusukan yang telah disisakan di dalam kecacatan-kecacatan dan meningkatkan penyerakkan bahan penusukan kesisian.*
 - (5) *Suhu pengeringan yang tinggi akan meningkatkan penyejatan penusukan. Ini menghalang bahan penusukan dari menyentuh bahan penyerlah dan menyebabkan kecacatan tidak dapat dikesan.*
 - (6) *Agen-agen permukaan dan penyerakan digunakan untuk membolehkan bahan penyerlah basah nanoakuas menyaluti bahagian permukaan secara sekata apabila ia disembur.*
 - (7) *Adalah penting untuk bahan penyerlah tidak digoncang sebelum digunakan agar muncung semburan tidak tersumbat.*
 - (8) *Suatu kecacatan yang dikesan pada permukaan bahagian adalah lebih berbahaya daripada kecacatan bersaiz sama yang terletak di bawah bahagian permukaan.*

- (9) *Retakan-retakan kecil mungkin menunjukkan satu garisan yang terputus-putus.*
- (10) *Semua kecacatan adalah boleh dibuang.*
- (11) *Salah satu cara untuk menentukan bahan penunjuk itu sesuai ialah dengan menyemburkan sebahagian kecil larutan di atas bahagian permukaan dan perhatikan pengulangan jujukan keluar.*
- (12) *Seseorang penyelidik tidak perlu mengambil kira untuk mencatatkan ciri-ciri yang tepat pada bahagian yang gagal.*
- (13) *Adalah dicadangkan dicantumkan semula permukaan-permukaan patah untuk melihat sekiranya ia berpadanan.*
- (14) *Satu tatacara lazim adalah dengan menyembur pada tempat patah menggunakan enamel atau akrilit bersih untuk menghasilkan artifak yang mungkin mengelirukan atau untuk menjelaskan perencatan patah.*
- (15) *Kelembapan yang terhasil daripada proses pembersihan boleh memberi kesan yang besar terhadap keupayaan bahan penusukan keluar ke bahagian permukaan dan menghasilkan tindakan kapilari.*
- (16) *Pembersihan sesuatu bahagian adalah perlu untuk menyingkirkan sebarang bahan pencemar yang mungkin mengganggu proses pemeriksaan.*
- (17) *Bahan-bahan pencemar bukan organik adalah bahan-bahan seperti karat, kotoran, endapan mineral, plastik dan garam.*
- (18) *Pembersih beralkali adalah bahan pencuci yang boleh menghilangkan beberapa jenis bahan pencemar organik. Ini termasuklah kebanyakan bahan-bahan pencemar berasaskan minyak.*

- (19) *Pembersihan ultrasonik hanya boleh menyingkirkan bahan-bahan pencemar organik.*
- (20) *Adalah penting bahawa proses pembersihan dilakukan sedikit punaran pada bahagiannya.*
- (21) *Salutan tebal atau cat tidak dicadangkan apabila melakukan ujian penusukan cecair.*
- (22) *Bahan-bahan pencemar bukan organik adalah bahan-bahan seperti minyak, cat, varnis dan pelincir.*
- (23) *Bentuk sesuatu bahagian tidak akan menghasilkan lebih topengan latar.*
- (24) *Bahagian-bahagian yang memerlukan pemasangan juga boleh memperlihatkan penunjuk-penunjuk yang tidak bersesuaian yang memerlukan penjelasan.*
- (25) *Di sepanjang hayat cahaya hitam, habuk dan kekotoran yang terkumpul pada permukaan sesuatu penapis akan mengurangkan tahap kepekaannya.*
- (26) *Blok-blok retakan magnesium adalah blok ujian yang lazim digunakan untuk menilai keupayaan penusukan.*
- (27) *Adalah lebih baik membiarkan cahaya hitam dibuka untuk keseluruhan tempoh anjakan daripada membiarkan ia dibuka dan ditutup di sepanjang tempoh anjakan.*
- (28) *Suatu panel ujian keupayaan sistem penusukan boleh digunakan untuk menguji kebolehasuhan penusukan tersebut.*
- (29) *Panel-panel ujian keupayaan sistem tidak akan dicemari dan ia memerlukan penggantian.*

- (30) *Mentol kalimantang bertekanan rendah adalah baik untuk penyucian keluar lebih penusukan berpendarfluor dan untuk pemeriksaan akhir.*
- (31) *Apabila panel "TAM" diuji, bilangan retakan-retakan bintang yang boleh dikenalpasti digunakan untuk menentukan penusukan berpendarfluor.*
- (32) *Pengenalpastian terbaik bagi kewujudan kecacatan-kecacatan adalah apabila wujudnya minimum 4 kaki candela bagi cahaya putih atau terjadinya cahaya latar.*
- (33) *Transformer yang menggunakan cahaya hitam dapat membantu mengatur perubahan garisan voltan.*
- (34) *Cahaya ultraviolet mempunyai jarak gelombang di bawah cahaya nampak.*
- (35) *Suhu bagi perumah dan penapis boleh menjadi amat panas.*
- (36) *Panel TAM mempunyai 2 sisi ketara. Sisi kasar digunakan untuk menentukan kebolehasuhan bahan penusukan.*
- (37) *Keamatan cahaya hitam berubah dengan garis voltan.*
- (38) *Sentiasa mengendali cahaya hitam tanpa penapis di tempatnya.*
- (39) *Masa minimum inapan penusukan adalah berdasarkan tatacara yang telah ditetapkan.*
- (40) *Jika bahagian yang diperiksa adalah terlalu besar untuk tangki bahan penusuk, kaedah semburan boleh digunakan.*
- (41) *Suatu bahagian perlu diputar atau dicelup semula supaya bahagian tersebut dapat liputan penuh.*

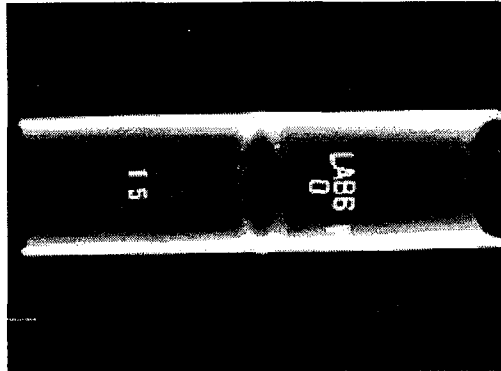
- (42) *Bahagian yang lebih panas memerlukan masa inapan lebih panjang.*
- (43) *Apabila bahan penusuk telah lengkap memasuki sesuatu kecacatan, masa inapan yang lebih panjang tidak akan menambah baik keputusan.*
- (44) *Jujuhan keluar bahan penusukan dari suatu retakan akan kelihatan membulat.*

(100 markah)

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2. For each objective question listed below, choose only one correct answer.
(You may answer on the page and attach it with answer scripts)

1. A radiographic image with a discontinuity located somewhere within it.



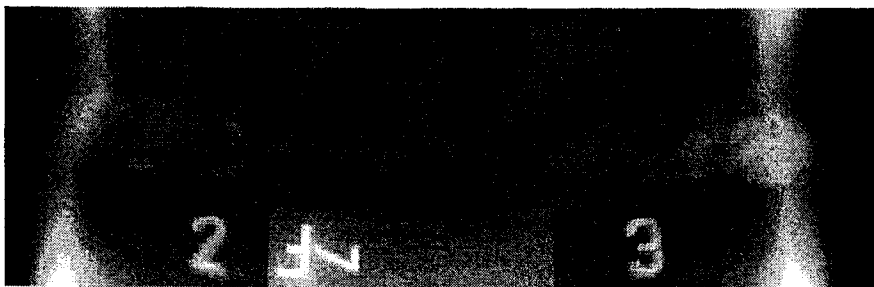
- (A) Slag
(B) Tungsten inclusion
(C) Porosity
(D) Incomplete
2. In any failure analysis investigation some features should be recorded include :
- (A) Origin of Failure
(B) Location of stress concentrators
(C) Direction of crack propagation
(D) All of the above
3. The protective spray can be removed later using :
- (A) Trichloroethylene
(B) Water
(C) Acetone
(D) Oil

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4. Vapour degreasing is used to remove organic contaminants such as :

- (A) Varnish
- (B) Rust
- (C) Grease
- (D) All of the above

5. A radiographic image with a discontinuity located somewhere within it.

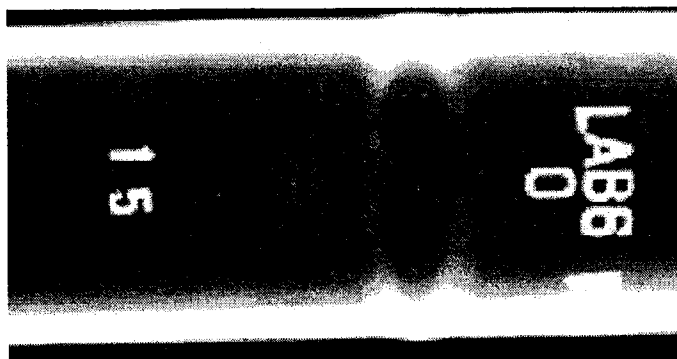


- (A) Mismatch
- (B) Insufficient fill
- (C) Excessive fill
- (D) Subsurface crack

6. If the wrong cleaning material is used, the part may be damaged due to :

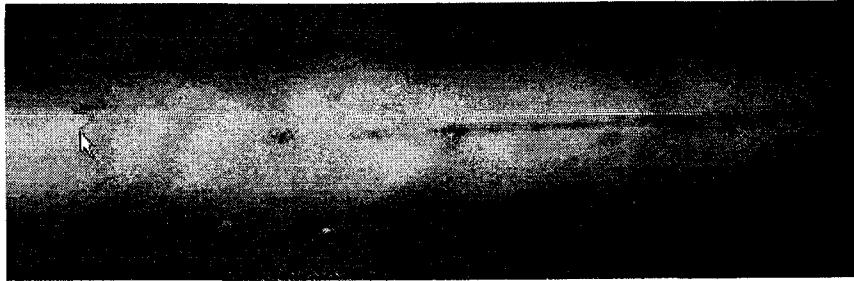
- (A) Rusting
- (B) Residue on the surface
- (C) Corrosion
- (D) All of the above

7. When a part has not been magnetized :
- (A) The magnetic domains are not orientated in any particular direction
 - (B) The magnetic domains are aligned between the north and south poles
 - (C) The magnetic domains repel each other
 - (D) The part becomes more conductive
8. The objective a visual image of an indication on the surface of a material.
- (A) Obtain a visual image of an indication on the surface of a material
 - (B) Disclose the nature of a discontinuity without impairing the part's usefulness.
 - (C) Determine acceptable from rejectable discontinuities
 - (D) All of the above apply
9. A radiographic image with a discontinuity located somewhere within it.



- (A) External Undercut
- (B) Weld spatter
- (C) Burn Through
- (D) Scatter porosity

10. A radiographic image with a discontinuity located somewhere within it.



- (A) Burn through
(B) Offset or Mismatch
(C) Lack of root fusion or lack of penetration
(D) Transverse crack
11. The most common application of penetrant is by :
- (A) Dipping
(B) Spraying
(C) Swabbing
(D) Only (A) and (B)
12. Emulsification times can vary from :
- (A) 15 seconds to 5 minutes
(B) 5 to 10 minutes
(C) 5 seconds to 10 minutes
(D) 5 to 15 minutes
13. If stress corrosion is suspected "
- (A) A minimum of 10 minutes is recommended
(B) A minimum of 30 minutes is recommended
(C) A minimum of 1 hour is recommended
(D) A minimum of 4 hours is recommended

14. The more complicated the part :
- (A) The less time it will take to remove the excess penetrant
 - (B) The more time it will take to remove the excess penetrant
 - (C) The shorter the dwell time needed in order for the penetrant to enter discontinuities
 - (D) The longer the dwell time needed in order for the penetrant to enter discontinuities
15. Excessive removal of penetrant will :
- (A) Reduce the bleed-out from small discontinuities
 - (B) Require longer emulsification times
 - (C) Shorten the dwell time
 - (D) Reduce the brilliance of the indications resulting in small discontinuities missed
16. Which application method results in the least amount of penetrant needed to cover a part?
- (A) Dipping
 - (B) Immersion
 - (C) Spraying
 - (D) Pouring
17. The objective of magnetic particle testing is to :
- (A) Obtain a visual image of an indication on the surface of a material
 - (B) Disclose the nature of a discontinuity without impairing the part's usefulness
 - (C) Determine acceptable from rejectable discontinuities
 - (D) All of the above apply

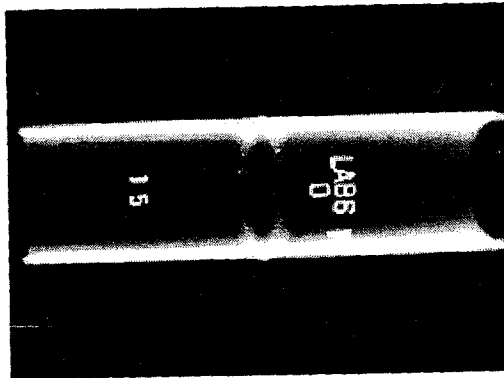
18. The north and south poles of a magnet will :
- (A) Repel each other
 - (B) Attract towards each other
 - (C) Attract or repel depending on the orientation of the domains
 - (D) Create a flux capacitance
19. Magnetic lines of force
- (A) Do not always form a closed loop
 - (B) Form a closed loop or circuit
 - (C) Exit the south pole and enter the north pole of a part
 - (D) Do not have any domains
20. What would easily attract towards any type of leakage field?
- (A) Aluminum particles
 - (B) Alloy particles
 - (C) Magnesium particles
 - (D) Iron particles
21. Which type of material has a slight repelling effect when a magnetic field is applied?
- (A) Diamagnetic materials
 - (B) Paramagnetic materials
 - (C) Ferromagnetic materials
 - (D) Sterromagnetic materials

22. In which direction does the magnetic field travel when current is travelling through a wire or a central conductor?
- (A) In the same direction as the current
 - (B) In a circular pattern around the wire
 - (C) There is no magnetic field when current is applied
 - (D) None of the above apply
23. The ease in which a material can be magnetized is called :
- (A) Permeability
 - (B) Reluctance
 - (C) Residual magnetism
 - (D) Retentivity
24. The best magnetic flux leakage can be obtained when the magnetic field is :
- (A) Parallel to the lines of force
 - (B) Perpendicular to the lines of force
 - (C) At 45 degrees to the lines of force
 - (D) Showing sign of relative permeability

(100 marks)

2. Untuk setiap soalan objektif tersenarai di bawah, pilih satu jawapan sahaja.
(Anda boleh menjawab pada kertas soalan dan kepilkan dengan skrip jawapan)

1. Imej radiografi dengan kecacatan terletak di dalam lingkungannya



- (A) Jermang
(B) Rangkuman Tungsten
(C) Keliangan
(D) Ketidaksempurnaan
2. Di dalam mana-mana penyiasatan analisis gagal beberapa ciri perlu direkodkan termasuk :
- (A) Asalan kegagalan
(B) Kedudukan tumpuan tegasan
(C) Arah perambatan retak
(D) Semua di atas
3. Semburan perlindungan boleh disingkirkan kemudiannya menggunakan :
- (A) Trikloroetilena
(B) Air
(C) Aseton
(D) Minyak

SECTION B**BAHAGIAN B**

3. [a] The investigator visually studies the fracture and its surrounding area. He records pertinent features photographically or schematically with certain procedure. List these features, the basic of procedure and the usual sequence of operations in the examination?

(50 marks)

- [b] Many commercial aircraft application involve the use of multiple fasteners to connect the multi-layer skins. Sliding probes are an efficient method of inspection. Describes the method of inspection and crack signal interpretations.

(50 marks)

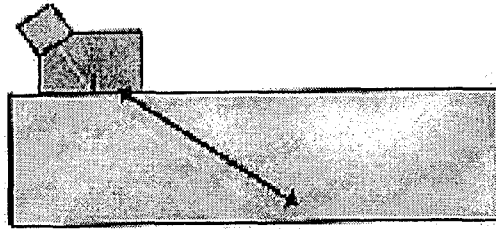
3. [a] *Penyelidik selalunya membuat kajian terhadap keadaan patah dan kawasan sekelilingnya. Beliau akan mencatat ciri-ciri fotografik yang tepat atau mengikut panduan-panduan dengan tatacara tertentu. Senaraikan ciri-ciri ini, tatacara asas dan aturan lazim operasi dalam pemeriksaan?*

(50 markah)

- [b] *Kebanyakan aplikasi kapal terbang komersil menggunakan pelbagai pengikat untuk menyambung pelbagai lapisan dinding. Gelongsoran kuar adalah satu kaedah yang tepat untuk pemeriksaan dilakukan. Terangkan kaedah pemeriksaan ini dan isyarat pentafsiran retak.*

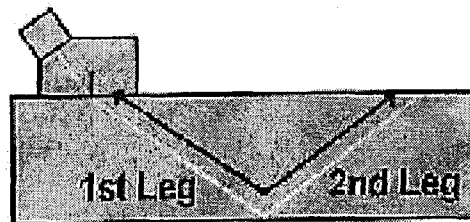
(50 markah)

4. [a] Calculate the $\frac{1}{2}$ V-path for Transducer with Angle 60° and Part thickness is 6.25 cm.



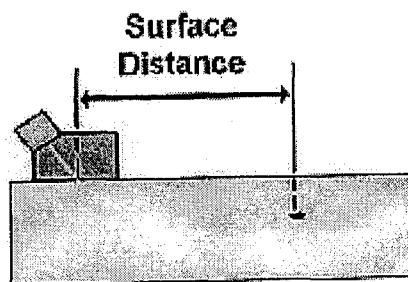
(15 marks)

- [b] Calculate the full V-path for Transducer with Angle 45° for Part with a thickness of 10 cm.



(15 marks)

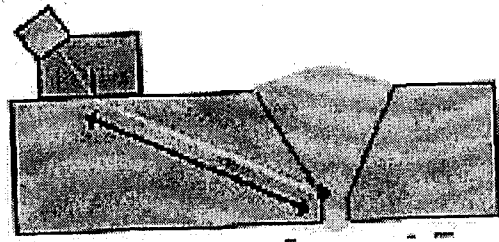
- [c] Calculate the surface distance for Transducer Angle 45° Part thickness 15 cm.



(15 marks)

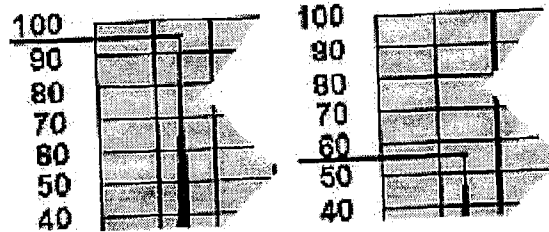
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- [d] Calculate the depth of the defect using Transducer with Angle 45°
Sound Path is 12.5 mm and the sample thickness 25 mm.



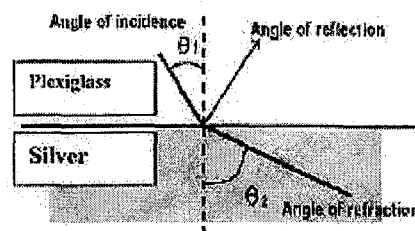
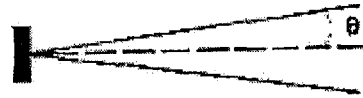
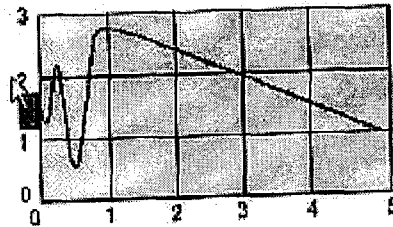
(15 marks)

- [e] In calibration of ultrasonic testing it was found the amplitude of 1st Signal (A1) Percent Full Screen Height (FSH) is 95 and the amplitude of 2nd Signal (A2) Percent Full Screen Height (FSH) is 55. Calculate the amplitude ratio.



(15 marks)

- [f] Calculate (1) the near field (2) the beam spread for the following materials; Bronze, stainless 410 and Plexiglass using Transducer having a diameter 12.5 mm and frequency 1.5 MHz. (3) calculate the Angle of Refraction in the silver if the sound coming from the Plexiglass with incident angle of 20° .

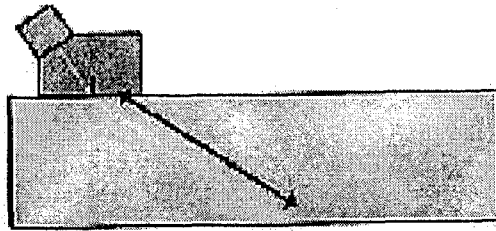


	Longitudinal Velocity Centimeters per microsecond	Shear Velocity Centimeters per microsecond
Aluminum 250	0.635	0.310
Aluminum 17st	0.625	0.279
Beryllium	1.280	0.787
Bronze	0.353	0.201
Cast Iron	0.450	0.240
Copper	0.466	0.226
Gold	0.324	0.120
Lead	0.216	0.070
Nickel	0.563	0.296
Plexiglass	0.267	0.112
Silver	0.360	0.159
Stainless 302	0.566	0.312
Stainless 410	0.739	0.299
Steel	0.585	0.323
Tin	0.332	0.167
Water	0.149	-----
Zinc	0.417	0.241

(25 marks)

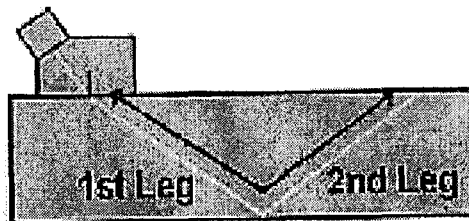
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4. [a] Kirakan V -laluan $\frac{1}{2}$ untuk transducer dengan sudut 60° dan ketebalan bahagian adalah 6.25 cm.



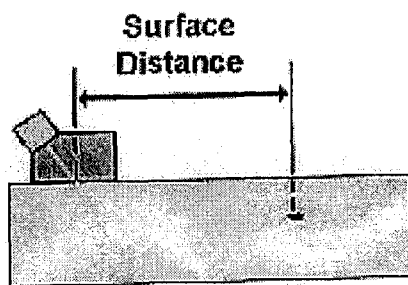
(15 markah)

- [b] Kirakan V -laluan sempurna untuk transducer dengan sudut 45° pada ketebalan bahagian 10 cm.



(15 markah)

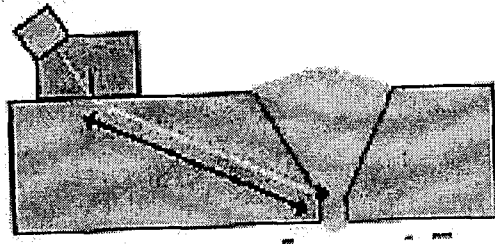
- [c] Kirakan jarak permukaan suatu transducer bersudut 45° dengan ketebalan 15 cm.



(15 markah)

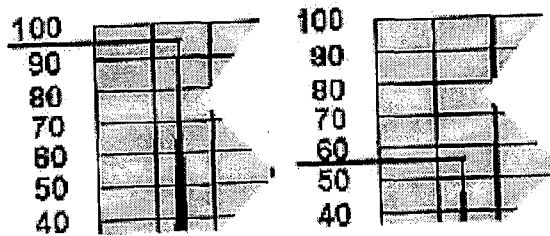
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- [d] Kirakan kedalaman kecacatan menggunakan transducer dengan sudut 45° .
Laluan bunyi adalah 12.5 mm dan ketebalan sampel adalah 25 mm.



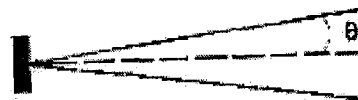
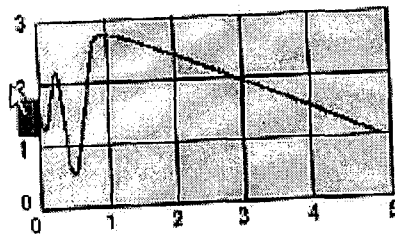
(15 markah)

- [e] Berdasarkan penentuan ujian ultrasonik, didapati bahawa amplitud isyarat pertama (A1) FSH ialah 95 dan amplitud isyarat kedua (FSH) ialah 55. Kirakan nisbah amplitud,

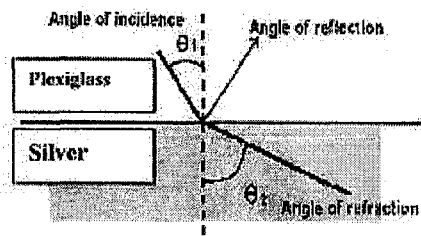


(15 markah)

- [f] Kirakan (1) medan terdekat (2) capahan alir untuk bahan-bahan berikut; gangsa, nirkarat 410 dan plexiglass menggunakan transducer berdiameter 12.5 mm dan frekuensi 1.5 MHz (3) kirakan sudut biasan perak jika sudut tuju bunyi yang datang daripada plexiglass adalah 20° .



...31/-



Longitudinal Shear
Velocity Velocity
Centimeters per microsecond

Aluminum 250	0.636	0.310
Aluminum 17st	0.625	0.279
Beryllium	1.280	0.787
Bronze	0.353	0.201
Cast iron	0.450	0.240
Copper	0.466	0.226
Gold	0.324	0.120
Lead	0.216	0.070
Nickel	0.563	0.296
Plexiglass	0.267	0.112
Silver	0.360	0.169
Stainless 302	0.566	0.312
Stainless 410	0.739	0.299
Steel	0.585	0.323
Tin	0.332	0.167
Water	0.149	-----
Zinc	0.417	0.241

(25 markah)

5. [a] Outline some characteristics of brittle fracture and describes two types of fracture modes in brittle materials. You are encouraged to include typical models for the explanation.
(30 marks)
- [b] Under certain conditions, some metals are subjected to diffusion of embrittling elements or compounds to the grain boundaries. Describe the types of major embrittlements in steel.
(40 marks)
- [c] Describe the influence of principal normal stresses on the shape of dimples formed by microvoids coalescence. Three principal normal stresses are in tension, shear and tensile tearing modes.
(30 marks)
5. [a] *Terangkan beberapa sifat patah rapuh serta jelaskan dua jenis kegagalan rapuh. Anda disyorkan menggunakan model tertentu untuk penjelasan.*
(30 markah)
- [b] *Di bawah keadaan tertentu, sebahagian logam dikenakan resapan elemen perapuhan atau sebatian, kepada sempadan butiran. Jelaskan jenis-jenis elemen perapuhan logam tersebut.*
(40 markah)
- [c] *Terangkan kesan tegasan normal utama terhadap bentuk kelompang yang terhasil melalui tautan mikrolompang. Tiga tegasan normal utama adalah dalam keadaan tegangan, ricih dan mod pengoyakan tegangan.*
(30 markah)

6. [a] Describe three typical steps of fatigue fracture. (35 marks)
- [b] Give clear explanation on two types of macroscopic characteristics of fatigue fracture (30 marks)
- [c] State the differences between striations and beachmarks in fatigue fracture. (35 marks)
6. [a] *Jelaskan tiga proses utama di dalam patah lesu.* (35 markah)
- [b] *Berikan penerangan yang jelas tentang dua jenis sifat makroskopik patah lesu.* (30 markah)
- [c] *Berikan perbezaan-perbezaan di antara calaran dan alunan di dalam patah lesu.* (35 markah)

7. [a] Give brief explanations about thermal, metallurgical and mechanical residual stresses
(45 marks)
- [b] Explain the possible preventive measures for galvanic corrosion.
(30 marks)
- [c] Explain the effective measures in preventing crevice corrosion and describe the unique characteristic of stress-corrosion cracking problems.
(25 marks)
7. [a] *Berikan penjelasan mengenai tegasan-tegasan bakian terma, metalurgi dan mekanik.*
(45 markah)
- [b] *Terangkan langkah-langkah pencegahan kepada kakisan galvani.*
(30 markah)
- [c] *Jelaskan langkah-langkah efektif untuk mencegah kakisan celah dan terangkan sifat-sifat unik bagi masalah retakan kakisan tegangan.*
(25 markah)