

Assessment 2

2019 / 2020

FACULTY OF: APPLIED DESIGN AND ENGINEERING

NAME OF COURSE/PROGRAMME:

YEAR OR LEVEL:

Level 7

NAME OF MODULE:

Structural Integrity & Materials Evaluation

Submission Date: 20th May 2020

Instructions to candidates: Answer all questions. Submission through turn-it in.

Question 1 – Total 20 Marks

- a) In table 1, you have been provided with through wall thickness measurements in mm and basic error analysis results undertaken as part of a larger POD study used to assess the performance of a new ultrasonic thickness gauging procedure. These results are also presented in graphical form in figure 1, where linear trend lines have been fitted to the data sets. There are 21 defect measurements in total, the dimensions of which are given in mm to 1 decimal place. 10 technicians have used the equipment and procedure to perform the measurements.

By analysing these results, comment on the relative sizing accuracy and general performance of each operator. How would you assess the performance of the procedure as a whole? **15 marks**

- b) Table 2 provides hit-miss data for complimentary NDT methods used to inspect an aircraft component. The technicians were required to report defects detected or not on a location-by-location basis. Carry out a full POD analysis using the ROC method. **5 marks**

Question 2 – Total 15 Marks

- a) A micro-focus 2D x-ray inspection is to be undertaken on a rectangular (4mm x 6mm) CFRP plate of thickness 2mm. The source to detector distance is fixed at 0.25m and the digital detector is a 2D CCD array 4096 x 4096 pixels and dimensions 0.8mm x 0.8m. The focal spot size of the x-ray tube is 30 μ m. A geometric unsharpness value (U_g) of better than 0.025mm is required. Calculate (i) the required source to object distance, (ii) the dimensions of the imaged object in detector pixels, and (iii) the system measurement accuracy in pixels. **5 marks**
- b) The intensity of an unshielded I-131 source is 140mR/hr. Determine the thickness of lead that is required to reduce this radiation down to 92nR/hr. Assume your distance from the source has not changed. The HVL of lead for I-131 is 0.178cm. **4 marks**
- c) A technician is in an area for 35 minutes and the reading on an exposure meter is 0.75mR/hr. Determine the actual radiation dose received by the technician. **1 mark**
- d) The technician should not receive a radiation dose greater than 1.5mR. Based upon the conditions in c) determine the maximum time the technician can stay in the area. **1 mark**
- e) For an x-ray tube voltage of 90kV determine (i) the maximum electron kinetic energy, and (ii) λ_{swl} (short wavelength limit) value for the brekling radiation process. **2 marks**
- f) An X-Ray tube has a copper anode with K, L and M electron shell binding energy levels of 8.98, 0.93 and 0.07 KeV respectively. Determine the wavelengths at which the K_α and K_β characteristic radiation lines would occur. **2 marks**

Question 3 – Total 15 Marks

- a) With reference to induced eddy currents in a conductor, explain the skin effect and effective depth of penetration. **5 marks**
- b) Explain the effects of shielding on an eddy current coil **4 marks**
- c) A test coil is used to inspect an aluminium component 0.5mm in thickness. Assuming 0.15mm as the standard depth of penetration required and that the conductivity of aluminium is 64.94 %IACS:
 - i) Calculate the required test frequency. **1 Mark**
 - ii) What would be the maximum phase difference between the induced near and far-surface eddy currents? **2 Marks**
 - iii) If we were to increase the test frequency by an order of 2, what would the effects be regarding the depth of penetration and near and far surface phase differences? **3 Marks**

Table 1. For use with Question 1

		Operator 1		Operator 2		Operator 3		Operator 4		Operator 5		Operator 6		Operator 7		Operator 8		Operator 9		Operator 10	
Defect	true size	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error	Estimate	Error
1	0.250	0.400	-0.150	0.500	-0.250	0.000	0.250	0.500	-0.250	0.000	0.250	1.000	-0.750	0.500	-0.250	1.000	-0.750	0.800	-0.550	0.495	-0.245
2	0.270	1.000	-0.730	1.200	-0.930	0.500	-0.230	1.000	-0.730	0.000	0.270	1.000	-0.730	0.500	-0.230	1.000	-0.730	0.800	-0.530	0.727	-0.457
3	0.280	0.800	-0.520	1.000	-0.720	1.200	-0.920	0.500	-0.220	0.000	0.280	1.000	-0.720	0.500	-0.220	1.000	-0.720	1.300	-1.020	0.758	-0.478
4	0.400	0.900	-0.500	0.500	-0.100	1.000	-0.600	1.000	-0.600	1.000	-0.600	1.200	-0.800	0.600	-0.200	1.000	-0.600	1.500	-1.100	0.910	-0.510
5	0.400	0.800	-0.400	1.200	-0.800	1.000	-0.600	1.200	-0.800	1.000	-0.600	1.400	-1.000	0.200	0.200	1.000	-0.600	1.600	-1.200	0.980	-0.580
6	0.500	0.400	0.100	0.900	-0.400	1.000	-0.500	0.800	-0.300	1.000	-0.500	1.100	-0.600	0.000	0.500	1.200	-0.700	1.000	-0.500	0.790	-0.290
7	0.520	0.700	-0.180	1.500	-0.980	1.100	-0.580	1.000	-0.480	1.500	-0.980	0.900	-0.380	1.000	-0.480	1.000	-0.480	0.900	-0.380	1.012	-0.492
8	0.550	0.500	0.050	1.200	-0.650	0.800	-0.250	1.200	-0.650	0.900	-0.350	0.500	0.050	1.300	-0.750	1.000	-0.450	1.600	-1.050	0.955	-0.405
9	0.700	1.200	-0.500	1.500	-0.800	0.900	-0.200	1.000	-0.300	1.600	-0.900	2.000	-1.300	1.600	-0.900	1.000	-0.300	2.000	-1.300	1.350	-0.650
10	0.980	1.500	-0.520	1.000	-0.020	0.800	0.180	1.600	-0.620	2.000	-1.020	1.900	-0.920	0.500	0.480	1.000	-0.020	1.800	-0.820	1.308	-0.328
11	1.120	1.200	-0.080	0.500	0.620	1.000	0.120	1.800	-0.680	1.800	-0.680	1.000	0.120	1.800	-0.680	1.500	-0.380	2.000	-0.880	1.372	-0.252
12	1.150	1.500	-0.350	1.800	-0.650	1.300	-0.150	1.500	-0.350	1.000	0.150	2.000	-0.850	1.800	-0.650	1.500	-0.350	2.000	-0.850	1.555	-0.405
13	1.100	1.700	-0.600	2.000	-0.900	1.400	-0.300	1.500	-0.400	1.600	-0.500	2.000	-0.900	0.500	0.600	2.000	-0.900	2.200	-1.100	1.600	-0.500
14	1.300	1.800	-0.500	2.100	-0.800	0.900	0.400	2.000	-0.700	2.000	-0.700	2.000	-0.700	1.700	-0.400	1.500	-0.200	2.000	-0.700	1.730	-0.430
15	1.600	1.400	0.200	0.800	0.800	0.900	0.700	1.500	0.100	2.000	-0.400	2.200	-0.600	1.200	0.400	2.000	-0.400	2.000	-0.400	1.560	0.040
16	1.800	1.300	0.500	2.000	-0.200	1.400	0.400	3.200	-1.400	2.000	-0.200	2.500	-0.700	2.200	-0.400	2.500	-0.700	2.500	-0.700	2.140	-0.340
17	2.100	2.500	-0.400	1.800	0.300	2.300	-0.200	3.000	-0.900	2.500	-0.400	3.500	-1.400	2.000	0.100	2.000	0.100	3.200	-1.100	2.490	-0.390
18	2.700	2.500	0.200	3.000	-0.300	3.200	-0.500	3.500	-0.800	2.500	0.200	2.800	-0.100	2.500	0.200	3.500	-0.800	3.500	-0.800	2.970	-0.270
19	4.900	5.500	-0.600	4.500	0.400	4.500	0.400	4.000	0.900	4.500	0.400	5.700	-0.800	4.200	0.700	5.500	-0.600	5.400	-0.500	4.870	0.030
20	6.000	6.500	-0.500	5.500	0.500	6.200	-0.200	5.500	0.500	6.500	-0.500	7.000	-1.000	5.300	0.700	6.500	-0.500	6.700	-0.700	6.170	-0.170
21	7.500	6.500	1.000	6.000	1.500	6.250	1.250	7.000	0.500	7.200	0.300	8.000	-0.500	6.500	1.000	8.000	-0.500	6.900	0.600	6.985	0.515
		σ	0.429	σ	0.676	σ	0.514	σ	0.531	σ	0.461	σ	0.382	σ	0.551	σ	0.254	σ	0.411	σ	0.258
		$\pm 95\%$	0.841	$\pm 95\%$	1.325	$\pm 95\%$	1.007	$\pm 95\%$	1.041	$\pm 95\%$	0.903	$\pm 95\%$	0.749	$\pm 95\%$	1.081	$\pm 95\%$	0.498	$\pm 95\%$	0.805	$\pm 95\%$	0.506

Figure 1 – For use with Question 1.

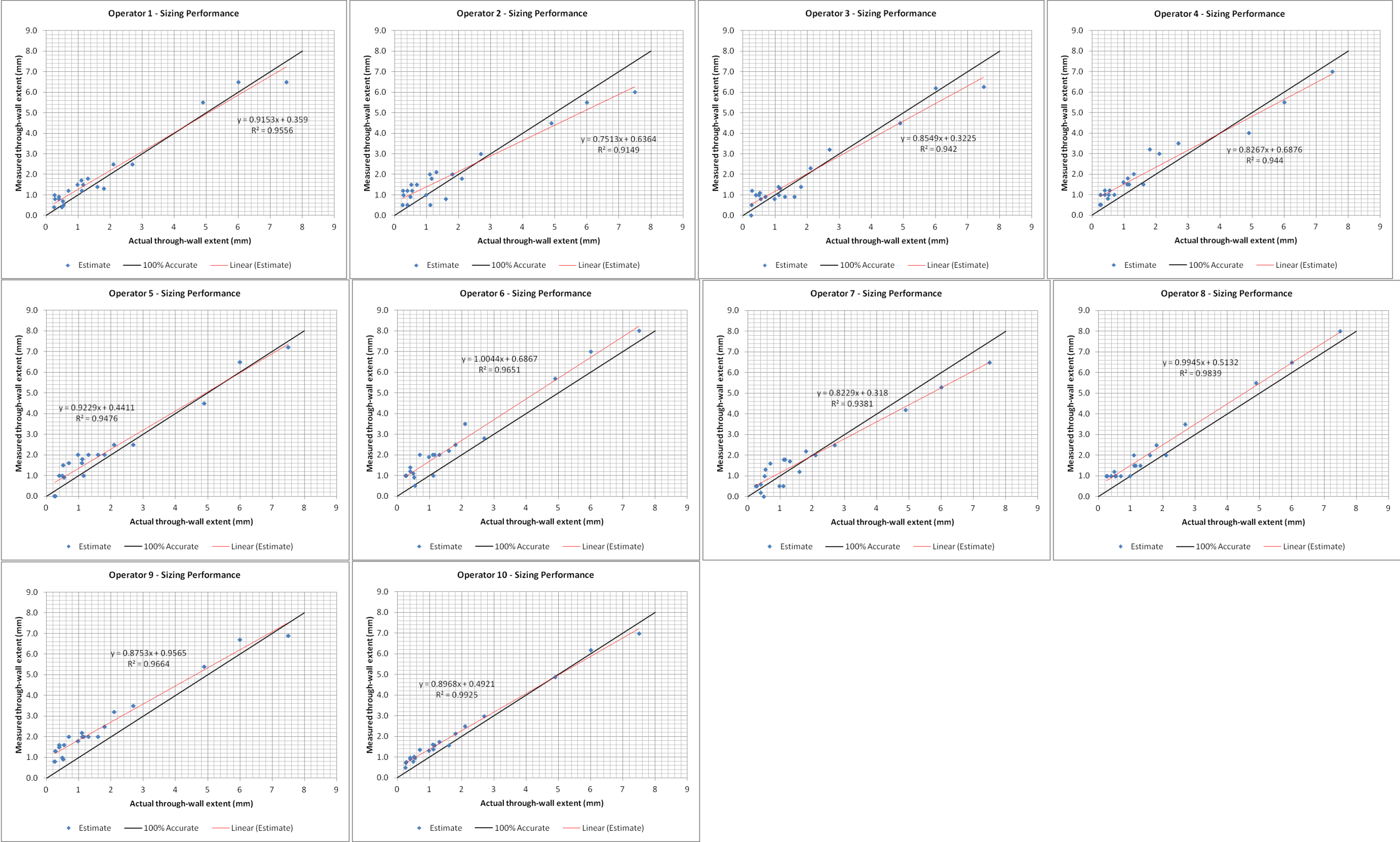


Table 2. For use with Question 2.

Location	Defect	Method 1	Method 2	Method 3
1	Y	1	0	1
2	Y	1	1	1
3	N	0	0	0
4	Y	1	1	1
5	N	1	0	0
6	Y	0	0	1
7	Y	0	0	1
8	N	0	0	0
9	N	1	0	0
10	N	0	0	0
11	N	1	1	1
12	N	1	1	1
13	Y	0	1	1
14	N	0	0	0
15	N	0	0	0
16	Y	1	1	0
17	N	0	0	0
18	N	1	0	0
19	Y	1	0	1