NATURAL SCIENCE AND GENERAL PRINCIPLES OF AIRCRAFT

Based on "*international training standards*" promulgated by the *International Civil Aviation Organisation* (ICAO) in their Annex 1 Chapter 4 referenced training manual, the following foundation training syllabi adopts the referenced *Aircraft Maintenance Engineer* (AME) training standards that meets Australia's obligation under Article 37 of the Convention.

The academic level of background subjects such as mathematics and physics should be specified as a prerequisite to course entry. However, if this is not practical or possible, then mathematics and physics may be taught to the required level before the start of the aviation training course. Where the knowledge of mathematics and physics is only just below the required entry level, or it is felt that a refresher course in mathematics and physics would be advantageous to the students, then these subjects could be taught in parallel with the aviation subjects

In addition to the subjects which are of direct day-to-day concern to the responsibilities of the AME, the AME training should include a sound understanding of the academic aspects of aircraft and aviation operations. This background will provide the trainees with a more complete understanding of not only their working environment but also the wider scientific principles employed in aviation.

The selection of topics for the mathematics and physics syllabi as well as the type of course instruction must reflect the depth and breadth of knowledge required to fully complement the level required by the aviation subjects.

Understanding the subjects of mathematics, physics, technical drawing, etc. constitutes an important part of the AMEs training base. It will permit a more comprehensive operational understanding, develop general in-depth awareness of air transport operations, and improve communication with both flight crew members and other maintenance personnel, thereby improving the overall safety of the aircraft operation.

The duties envisaged for the AME require supervisory and communication skills, diagnostic prowess and a high degree of technical knowledge. The training courses should therefore be structured in such a way as to provide the trainees with sufficient ability to think logically and to apply their knowledge objectively. The courses should also help them develop physical skills that would enable them to carry out each task in a professional manner by using good engineering and maintenance practices. At the same time, it is also important for the trainees to develop a high degree of confidence, competence, initiative, team spirit and self-reliance so that they can perform well under varying and sometimes trying circumstances.

TRAINING OBJECTIVES

Annex 1 and Annex 6 have two requirements affecting aircraft maintenance personnel and which can be met by means of training. These are:

- Annex 1, Chapter 4, which concerns the issue of an aircraft maintenance licence compliant with Annex 1.
- Annex 6, Part I, 8.7.5.3, which requires that within an AMO, "*the competence of maintenance personnel (should) be established with a procedure and to a level acceptable to the State granting the approval*."

When designing courses and associated syllabi in order to enable individuals and AMOs to meet the training requirements of Annex 1, an aviation training centre should have the following goals in mind:

- to train an individual to enable him or her to meet the standard required for the issue of an AME licence by the State or its aviation regulatory body;
- to train AMO maintenance personnel to meet the standard of competence required by Annex 1 for signatories of maintenance release; and
- to train AMO maintenance personnel to meet the standard of competence required by that AMO and is approved by the State or its aviation regulatory body.

Many aviation training centres use different standards in training maintenance personnel for AMOs. While their training courses are not the subject of this manual, it is hoped that the use of training specifications outlined in this manual will enable individuals to gradually achieve the goals cited above.

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Mathematics: (Secondary/Tertiary)

4.3.1. Arithmetic

- Arithmetical terms and signs; methods of multiplication and division; fractions and decimals; factors and multiples; weights, measures and conversion factors; ratio and proportion; averages and percentages; areas and volumes; squares, cubes, square and cube roots.

4.3.2. Algebra

- Evaluation of simple algebraic expressions; addition, subtraction, multiplication and division; use of brackets; simple algebraic fractions, linear equations and their solutions; and introduction to simultaneous equations
- Polynomials and binomial theorem, solution of second degree equations with one unknown, solution of simultaneous linear equations, and use of complex numbers.

4.3.3. Geometry

- Simple geometrical constructions
- Graphical representation: nature and uses of graphs, rectangular and polar coordinates; graphs of equations
- Solution of plane triangles; solution of spherical triangles; application of some hyperbolic functions

4.3.4. Trigonometry

- Simple trigonometry: trigonometrical relationships and use of tables

4.3.5. Logarithms

- Indices and powers: negative and fractional indices; square root; reciprocal and exponential tables
- Logarithms: use of log tables, and logarithms of produces, quotients, powers and root

4.3.6. Calculators

- Use of electronic calculators for logarithmic and trigonometric applications

4.3.7. Differential and integral calculus

- Derivatives and differentials; maxima and minima; expansion in series; indeterminate forms; curvatures; table of indefinite integrals, definite integrals; differential equations encountered in physics

4.3.8. Graphical representation of functions

- Equations involving two variables; equations for empirical curves; use of logarithmic paper; equations involving three variables; alignment charts

Physics: (Secondary/Tertiary)

4.4.1. Mechanics

- Forces as vectors: scalars, vectors, resultants, triangle of vectors, polygon of vectors, and resolution of a vector
- Forces and moments, composition and resolution
- Centre of gravity
- Uniform motion in a straight line; acceleration; motion under gravity; Newton's Laws; momentum; force; mass and weight; work, energy, rate of doing work, potential energy, relative velocity, angular velocity, physical units of mass, force, speed, work and power
- Friction: nature and effects, and coefficient of friction
- Specific gravity and density
- Viscosity, fluid resistance and rolling resistance
- Pressure and buoyancy in liquids (barometers)
- Elements of fluid dynamics: streamlines, Bernouilli's Theorem, venturi, Pitot tube and speed of sound
- Elements of vibration theory: harmonic motion, pendulum, damped harmonic motion, forced harmonic motion, and resonance

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- Velocity ratio, mechanical advantage and efficiency
- Elements of theory on stress, strain and elasticity; tension, compression, shear and torsion stress; Hooke's Law and Young's Modulus
- Dynamics: kinematics of pure rotation, work, power, torque, kinetic energy, moment of inertia, radius of gyration, rotational equilibrium, centre of mass, couples, momentum and impulse, conservation of momentum, elastic and inelastic collisions, two-dimensional motion, and rolling bodies
- Elasticity: internal forces in solids, stress, strain, Hooke's Law, Poisson's ratio, shear, torsion, and bulk modulus
- Periodic motion: motion in a circle at constant speed, energy relations in simple harmonic motion, angular harmonic motion, and equilibrium of a dynamical system

4.4.2. Heat

- Temperature: thermometers and temperature scales (Celsius/Centigrade, Fahrenheit, Rankine and Kelvin); conversion from one scale to another
- Expansion: linear expansion, surface and volume expansion
- Quantity of heat: units of heat (calories, BTU, CHU), heat capacity and specific heat
- Heat transfer: convection, radiation and conduction
- Mechanical equivalent of heat, first and second laws of thermodynamics
- Properties of fluids: solid, liquid and gaseous states, melting, boiling, evaporation and reverse processes, vapour pressure, absolute and relative humidity
- Gases: ideal gas; Charles' and Boyle's Laws; internal energy of a gas; specific heat of a gas; relationship between internal energy and heat
- Latent heats of fusion and evaporation, thermal energy, and heat of combustion
- Gases: specific heat at constant volume and constant pressure; work done by expanding gas; kinetic theory of gases
- Avogadro's number
- Thermodynamics: isothermal expansion and compression; adiabatic expansion and compression; the Carnot cycle; engine cycles; constant volume and constant pressure; refrigerators and heat pumps

4.4.3. Light

- Introduction to nature of light; speed of light
- Laws of reflection and refraction: reflection at plane surfaces; reflection by spherical mirrors, refraction, lenses, cameras and projectors, microscopes and telescopes
- Propagation of light, illumination, and photometry
- Wave optics: interference, interferometers, Huygens' model, diffraction, diffraction gradings, and polarization
- Spectra: dispersion by refraction, spectrometers, emission and absorption spectra, and quanta

4.4.4. Electricity and magnetism

- Fundamentals: atoms and electrons, conductors and insulators, electric currents, electromotive force, difference of potential, electrical units, power, work and energy, Ohm's Law, specific resistance, series, parallel and combined DC circuits, Kirchoff's Laws and the Wheatstone Bridge
- Batteries and thermal EMF: theory of electrolysis, primary cells, secondary cells; lead-acid and alkaline accumulators; and thermocouples
- Magnetism: permanent magnets, laws of magnetism, the earth's magnetism, magnetic fields, electro-magnetism, polarity rules, field strength and flux density, permeability, hysteresis, and reluctance
- Electrostatics: positive and negative charges, charges developed by friction, electrostatic induction, surface charges, electrostatic fields, static charges on aircraft and methods of dispersing them
- Electromagnetic induction: Faraday's Laws, Lenz's Law, magnitude and direction of induced EMF, generators, and induction coils
- Inductance and capacitance: mutual inductance; self- inductance; unit of capacitance; specific inductive capacity; dielectric strength; losses and efficiency
- Outline of AC theory: generation, principles, single-phase and three-phase generation, measurement of current and voltage, RMS, audio and radio frequencies
- Resistance, inductance and capacitance in AC circuits: inductive reactance, resistance and inductance in series, impedance, power factor and true power, capacitive reactance, resistance and capacitance in series, resonance, Q factor, and voltage developed at resonance
- Resistance, inductance, capacity and parallel combinations
- Methods of coupling: mutual inductive coupling, resistive coupling, auto-inductive coupling, capacitive coupling, equivalent resistance, equivalent reactance, coupling factor, and resonance curves

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- Transformers: primary and secondary EMF; load-on secondary, resistive, inductive and capacitive loads; transformer losses; tests of transformers; X-rays and natural radioactivity; photoelectric and inverse photo-electric effect; generation of X-rays; radioactive substances; radiography with X-rays and gamma-rays Wave motion and sound
- Wave motion: mechanical waves, sinusoidal wave motion, interference phenomena, and standing waves
- Sound: speed of sound, production of sound, intensity, pitch and quality, and Doppler effect

Technical Drawing:

Introduction

- Purpose of technical drawing; Care and use of drawing instruments; Standard paper sizes, blocks, conventions for lines, and dimensions

4.5.1. Practice with drawing instruments

- Lettering; Simple geometric constructions; Layout of patterns with metric or inch dimensions

4.5.2. Simple orthographic projections

- Orthographic conventions; Practice in first angle projections; Practice in third angle projections

4.5.3. Simple isometric projections

- Isometric conventions; Practice in making workshop sketches

4.5.4. Geometric construction

- Constructions involving lines and angles, circles and conic sections;
- Geometric projections

4.5.5. Practice in sketching

- Proportioning; Orthographic sketching;
- Pictorial sketching

4.5.6. Orthographic projection

- Rules, determination of number of views, notation and representations, layout of three-view drawings, computation of weights; Sectional views, standard symbols for sections and materials; Dimensioning; Representation of machine elements, threads, bolts, nuts, rivets, etc.;
- Exercises incorporating standard conventions

4.5.7. Shop terms and processes

- Relationship between drawing and manufacturing processes; Drawings for castings, forgings, machined parts, sheet metal parts, and welded constructions
- Practices as appropriate to particular course

4.5.8. Assembly drawings

- Layout drawing; Assemblies, erection and installation drawings, inter- changeability, tolerances, fits and clearances, datum surfaces, tolerancing of form and position; Surface finish, finish marks and specifications
- Checking drawings

4.5.9. Auxiliary projections

- Notation and relationship of auxiliary planes; Layout of drawing with one auxiliary view; Layout of drawing with two auxiliary views

4.5.10. Axonometric projection

- Isometric projections, dimetric and trimetric projections; Theory of axonometric projections

4.5.11. Oblique projection

- Theory; Cavalier projection; Cabinet projection

4.5.12. Circuit layout

- Convention for electrical and radio components; Standard symbols for theoretical circuits and wiring diagrams

4.5.13. Exercises in blueprint reading

- Interpretation of blueprint data; Check for consistency

4.5.14. Exercises in engineering design

- To be selected by the instructor in accordance with the nature of the particular course and the type of work that the student will undertake in the future

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Chemistry:

- Nature of matter: the chemical elements; structure of atoms, molecules, crystals, colloids, solutions and solvents; hardness and ductility

Human Factors:

A: General programme overview

Purpose: Training goals and objectives

Content: Training content

Concepts: Human Factors concepts and definitions which form part of the course

Cost of maintenance errors

B: Human Factors knowledge (AME)

- Understanding maintenance operations as a system: seeing the "big picture"
- Understanding basic Human Factors issues and human limitations: vision, hearing, information processing, attention and perception, memory, and the associated ergonomic issues related to workplace and task design
- Recognizing the contributory causes to human errors: interactions with organizational procedures, groups and individual factors; reason model and the "Dirty Dozen"

C: Communication skills (AME)

- Understanding the consequences of poor communication
- Communication methods (written, verbal, etc.)
- Communication content: relevance, correctness, conciseness and completeness
- Communication purpose and target audience
- Communication behaviour/style: assertiveness, aggression and feedback
- Active listening, feedback, body language and facial expression
- Effective writing
- Recognizing approved or unapproved data
- Overcoming barriers to the use of approved data
- Shifting turnover/handover process

D: Teamwork skills (AME)

- Team definition and discrimination from group
- Team dynamics (positive/neutral)
- Team leadership: telling or selling, involving or delegating
- Team building
- Inter- and intra-team communication
- Coordination and decision-making
- Understanding the characteristics of an effective team
- Understanding norms, their definition and identification
- Effective meetings and different roles: chair, shaper, worker and finisher

E: Performance management (AME)

- Stress: identifying stressors e.g. communication, role conflict, others
- Pressure: be organized, get help and facts, and delegate
- Shift work: fatigue, working hours, sleep, stress, and environmental factors
- Complacency: identification and management

F: Situation awareness (AME)

- Error chain recognition and control
- Workload management: learning to say no
- Supervision and leadership

G: Human error (AME)

- Error models (latent and active)
- Error classification and prevention
- Task analysis: be proactive; "plan — do — check"; others
- Defences: documentation; don't assume — check and ask; others
- Changing conditions rather than changing people