Unit UEEENEEG106A
TERMINATE CABLES, CORDS & ACCESSORIES FOR LOW VOLTAGE CIRCUITS

KS01-EG106A
Class Orientation

Introduction:
- Introduce yourself.
- Welcome to Electrical Trades Miller TAFE.
- Miller is part of SWSI Institute.
- Check enrolment forms.
- Discuss the requirement to carry TAFE Card

General Induction:
- Discuss location of:
  - Toilets
  - Building exits
  - Evacuation area
  - Fire extinguishers
  - First aid
  - Emergency Stop buttons (class room induction)

- Refer to the STUDENT CALENDAR (in front of book) and discuss the following:
  - Use for important dates, exams, holidays etc.
  - Schedule exam make-up dates etc. (only in consultation with the class teacher)

- Refer to the STUDENT CONTACTS page (in front of book) and discuss the following:
  - Head Teachers phone number and office number
  - Teachers phone number and office number
  - College support unit contacts and phone number
  - Other college phone numbers

- Refer to the EVACUATION PLAN and discuss the following:
  - Fire and Bomb threat procedures
  - The evacuation procedure
  - The requirement to check the roll at the evacuation area

- Refer to the COLLEGE MAP and discuss the following:
  - Car parking
  - Canteen & operating hours
  - Phone (in canteen – free for local calls only)
  - Student Association (in canteen area)
  - Library & operating hours
  - Main Office

- Refer to the MINIMUM STUDENT REQUIREMENTS page and discuss the following:
  - Each item listed in the document
  - Break times and punctuality
  - Emphasise employer correspondence for non-adherence
  - Always have required PPE. ie: clear safety glasses, correct footwear etc.
  - Always carry required resources eg: pens, calculators, drawing instruments & standards
Class Orientation

- Refer to the USEFUL LINKS page and discuss the following:
  - Available websites and services
  - Login procedures for varying services and sites
  - Recording of students DEC User ID and Password
  - Procedure for downloading Australian Standards
  - Accessing Moodle courses

- Refer to the EQUATION SHEET and discuss the following:
  - Every new student workbook has an equation sheet
  - Only new / clean equation sheets will be permitted in exams
  - Not all exams require the use of an equation sheet

- Refer to the WORK PERFORMANCE EVIDENCE page and discuss the following:
  - A broad overview of workplace training
  - The need to collect evidence whilst at work
  - Skills Tracker recording – Login details etc.
  - Skills Tracker orientation will be done during the year
  - You cannot course complete without adequate work performance evidence

- Refer to the COURSE OUTLINE and discuss the following:
  - Four year apprenticeship (in general)
  - Three years at TAFE, fourth year in the workplace
  - The IMPORTANCE of evidence collection for Workplace Performance (Skills-tracker)
  - Options for failed units and repeat classes
  - Failing a unit twice

- Refer to the UNIT GUIDE and discuss the following:
  - Prerequisites, and the possible need to repeat a unit or part thereof before advancing
  - Student Assessment Guidelines and signing of guidelines for each unit
  - Consequences for Cheating
  - Contacting the class teacher for missed exams
  - Explain the SAGs assessment table and the timing / weighting of exams
  - Successful completion of a unit is only achieved when a student shows sufficient Essential Knowledge & Associated Skills (EKAS) contained within the unit, whereby;
    - Essential Knowledge is determined by the KS associated with the unit, and
    - Skills are demonstrated by consistent performance across a representative range of contexts.

NOTE: Evidence of skills may be collected in a number of ways. Examples include:

- Skills-tracker portfolios
- Workbook UNIT portfolios
- In class simulated workplace activities, documented in the class roll by the teacher
- A combination of all of the above.

Tour of Campus: - For new classes, visit required locations listed above
Evacuation Plan & Procedure


You MUST stay in your class group at the designated assembly area. Follow all instructions given to you by your class teacher.
F Block
Electrical Trades
Minimum Student Requirements

Electrical Trades Section - Miller

1. **SHOES / PPE**
   Fully enclosed leather-top shoes must be worn at all times in all parts of the building. **Definitely no thongs or sandals.**

2. **ATTIRE**
   Clean tidy clothing is required. Tops are required to have sleeves. **No singlet-style tops.**

3. **EYES / PPE**
   **Clear, non-tinted safety glasses** must be provided by the student and worn where required e.g. workshop classes.

4. **BOOKS**
   Each student must have his/her own text, tutorial and workbooks as well as any required accessories e.g. pens, drawing instruments, calculator, AS3000 rule book.

5. **ATTENDANCE**
   Students are expected to be punctual and attend classes for the entire duration. In the event of not being able to attend a class or classes, the student should inform the class teacher and their employer.

   Non-attendances will result in employers being notified.

6. **ASSESSMENTS**
   Students that miss exams for ANY reason must where possible contact their class teacher beforehand. Acceptable supporting evidence as to why the exam was missed MUST be provided. e.g. doctor certificate for illness. Refer to the ‘student assessment guidelines’ for further important information.

   - ‘SCHOOLIES’ is not an acceptable reason to miss exams.
   - Cheating and Plagiarism will not be tolerated

7. **SMOKING**
   Smoking is not permitted on the College grounds at any time. Please make your way to the College entrance on Banks Road.

8. **EATING**
   The consumption of food or drink is not permitted in any part of any building within the College (with the exception of the College Canteen).

9. **MOBILE PHONES**
   **Mobile phones are to be turned off** prior to entering any classroom, workshop or wiring room. Mobile phones are not to be accessed during class.

10. **DISCIPLINE**
    Students must be familiar with, and adhere to, the Code of Conduct which is printed in the Student Handbook that is available from the main office.
## Useful Links

<table>
<thead>
<tr>
<th>Service</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Skills-Tracker</td>
<td>An online resource used by individuals to gather and record their work performance evidence.</td>
</tr>
<tr>
<td><a href="http://www.skills-tracker.com">www.skills-tracker.com</a></td>
<td></td>
</tr>
<tr>
<td>Email: <a href="mailto:info@skills-tracker.com">info@skills-tracker.com</a></td>
<td></td>
</tr>
<tr>
<td>Phone: +612 9543 1100</td>
<td></td>
</tr>
<tr>
<td>Miller Electrical WIKI space</td>
<td>Find information about enrolments, calendars, contacts, help with maths, work performance evidence databases and lots more.</td>
</tr>
<tr>
<td><a href="http://electricaltrades-miller.sw.wikispaces.net">http://electricaltrades-miller.sw.wikispaces.net</a></td>
<td></td>
</tr>
<tr>
<td>Moodle</td>
<td>Access unit information for some classes (see your teacher). You may also need a specific ‘enrolment key’ to access your teachers class work on Moodle.</td>
</tr>
<tr>
<td><a href="http://swsi.moodle.tafensw.edu.au">http://swsi.moodle.tafensw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td>South Western Sydney Institute of TAFE</td>
<td>Find information about enrolments, college contacts and locations, courses, additional services and much more.</td>
</tr>
<tr>
<td><a href="http://www.swsi.tafensw.edu.au">www.swsi.tafensw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td>TAFE NSW Website</td>
<td>Find information about courses, colleges, assessment, a range of student services, career advice, and much more.</td>
</tr>
<tr>
<td><a href="https://www.tafensw.edu.au">https://www.tafensw.edu.au</a></td>
<td></td>
</tr>
<tr>
<td>State Training Services</td>
<td>For information regarding Skills Recognition, Craft Certificates, Certificates of Proficiency (COP), check apprenticeship registrations, access to Australian apprenticeship support services etc.</td>
</tr>
<tr>
<td>Vocational Training Tribunal (VTT) – 02 9266 8450</td>
<td></td>
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<tr>
<td>NSW Fair Trading</td>
<td></td>
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<tr>
<td>NSW Industrial Relations</td>
<td></td>
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<tr>
<td><a href="http://www.industrialrelations.nsw.gov.au">www.industrialrelations.nsw.gov.au</a></td>
<td>Find information for pay rates, long service and general award conditions.</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td><strong>USE THIS SPACE TO RECORD LOGIN DETAILS FOR SPECIFIC SITES</strong></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Password to log on to the TAFE computers</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>User name:</td>
<td>MIFG15-11 (e.g. ONLY)</td>
</tr>
<tr>
<td>Password:</td>
<td>tafestudent (all one word)</td>
</tr>
<tr>
<td>Log on to:</td>
<td>SOUTH_WESTERN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Password to log on to the Internet at TAFE</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>User name:</td>
<td>Your DEC User ID</td>
</tr>
<tr>
<td>Password:</td>
<td>Your DEC password</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Password to log on for library resources</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>User ID:</td>
<td></td>
</tr>
<tr>
<td>Password:</td>
<td></td>
</tr>
<tr>
<td>Changes yearly. See library staff</td>
<td></td>
</tr>
</tbody>
</table>

* It is strongly suggested that you record your User ID and password somewhere secure. Such as in your phone.
Useful Links

How to access Standards Online Premium
Access to SAI Global to download AS/NZS 3000 and other AS Standards.


2. Left click on Standards Online Indexes

3. Consult library staff for this years’ User ID and Password

4. Left click on Standards Online Indexes

5. Type in the Standard that you want to access
   Examples:
   AS/NZS 3008.1.1
   AS/NZS 3000:2007

6. From the search results, click on the required standard.
   You can open and view the file.

   Saved files expire after 2 days

** Library staff can also assist you to access Standards Online Premium on library computers **
Useful Links

How to access Moodle

The following is a guide to login to Moodle from an external computer (example: from home)

If you are accessing Moodle from a TAFE computer, you will need to login to the TAFE computer first. See the instructions on the first page of ‘Useful Links’.

1. Go to http://www.swsi.moodle.tafensw.edu.au

2. Login using your portal username and password.
   Note: This is your DEC Username and password.

3. New users – search for the course name (or part thereof) given to you by your class teacher.
   Example: ‘UEENEEE101A’ or ‘OHS’

4. If multiple courses of the same name appear, be sure to select the course name ending in ‘-mi’ for Miller TAFE
   Left click to enter course

5. Enter the enrolment key as given to you by your class teacher.
   Left click on the ‘Enrol me’ icon and access your course material.

6. Existing or returning users – left click on the ‘My home’ tab to see your previously registered courses. Access your course as per step 4. No enrolment key required.
**Stage 1:** This list does not contain all equations in the course and transposition may be required.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td>1</td>
<td>$Q = It$</td>
<td>$F = ma$</td>
<td>$W = Pt$</td>
<td>$W = Fs$</td>
<td>$W = mgh$</td>
</tr>
<tr>
<td>2</td>
<td>$V = IR$</td>
<td>$I = \frac{V}{R}$</td>
<td>$R = \frac{V}{I}$</td>
<td>$P = \frac{2\pi n T}{60}$</td>
<td>$\eta % = \frac{\text{output}}{\text{input}} \times \frac{100}{1}$</td>
</tr>
<tr>
<td>3</td>
<td>$P = VI$</td>
<td>$P = I^2 R$</td>
<td>$P = \frac{V^2}{R}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>$R = \frac{\rho l}{A}$</td>
<td>$R_2 = \frac{R_1 A_1 l_2}{A_2 l_1}$</td>
<td>$R_n = R_c(1 + \alpha \Delta t)$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>$V_T = V_1 + V_2 + V_3$</td>
<td>$R_T = R_1 + R_2 + R_3$</td>
<td>$I_T = I_1 = I_2 = I_3$</td>
<td>$V_1 = V_T \frac{R_1}{R_1 + R_2}$</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>$V_T = V_1 = V_2 = V_3$</td>
<td>$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$</td>
<td>$I_T = I_1 + I_2 + I_3$</td>
<td>$I_2 = I_T \frac{R_1}{R_1 + R_2}$</td>
<td>$R_T = \frac{R_1 R_2}{R_1 + R_2}$</td>
</tr>
<tr>
<td>7</td>
<td>$C = \frac{Q}{V}$</td>
<td>$C = \frac{A \varepsilon \varepsilon_r}{d}$</td>
<td>$\tau = RC$</td>
<td>$C_T = C_1 + C_2 + C_3$</td>
<td>$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$</td>
</tr>
<tr>
<td>8</td>
<td>$L = N \Delta \phi / \Delta l$</td>
<td>$L = \frac{N^2}{S}$</td>
<td>$\tau = \frac{L}{R}$</td>
<td>$V = N \frac{\Delta \phi}{\Delta t}$</td>
<td>$V = L \frac{\Delta l}{\Delta t}$</td>
</tr>
<tr>
<td>9</td>
<td>$e = Blv$</td>
<td>$F = Bil$</td>
<td>$F_m = IN$</td>
<td>$B = \frac{\phi}{A}$</td>
<td>$S = \frac{l}{\mu_0 \mu_r A}$</td>
</tr>
<tr>
<td>10</td>
<td>$E_g = k \phi n$</td>
<td>$T = k \phi I_a$</td>
<td>$T = Fr$</td>
<td>$H = \frac{F_m}{l}$</td>
<td>$\phi = \frac{F_m}{S}$</td>
</tr>
</tbody>
</table>
**Stage 2:** This list does not contain all equations in the course and transposition may be required.

**Stage 1:** equations are also used during stage 2

<table>
<thead>
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<tbody>
<tr>
<td>11</td>
<td>$V_{\text{ave}} = 0.637V_{\text{max}}$</td>
<td>$V_{\text{RMS}} = 0.707V_{\text{max}}$</td>
<td>$v = V_{\text{max}} \sin \theta$</td>
<td>$V_L = \sqrt{3}V_p$</td>
<td>$f = \frac{nP}{120}$</td>
</tr>
<tr>
<td>12</td>
<td>$I_{\text{ave}} = 0.637I_{\text{max}}$</td>
<td>$I_{\text{RMS}} = 0.707I_{\text{max}}$</td>
<td>$i = I_{\text{max}} \sin \theta$</td>
<td>$I_L = \sqrt{3}I_p$</td>
<td>$t = \frac{1}{f}$</td>
</tr>
<tr>
<td>13</td>
<td>$I = \frac{V}{Z}$</td>
<td>$V = IZ$</td>
<td>$Z = \frac{V}{I}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>$Z = \sqrt{R^2 + X^2}$</td>
<td>$Z = \sqrt{R^2 + (X_L - X_C)^2}$</td>
<td>$X_L = 2\pi f L$</td>
<td>$X_C = \frac{1}{2\pi f C}$</td>
<td>$\cos \theta = \frac{R}{Z}$</td>
</tr>
<tr>
<td>15</td>
<td>$P = VI \cos \theta$</td>
<td>$S = VI$</td>
<td>$Q = VI \sin \theta$</td>
<td>$P = \sqrt{S^2 - Q^2}$</td>
<td>$\cos \theta = \frac{P}{S}$</td>
</tr>
<tr>
<td>16</td>
<td>$P = \sqrt{3}V_L I_L \cos \theta$</td>
<td>$S = \sqrt{3}V_L I_L$</td>
<td>$Q = \sqrt{3}V_L I_L \sin \theta$</td>
<td>$\tan \theta = \sqrt{3} \left( \frac{W_1 - W_2}{W_1 + W_2} \right)$</td>
<td>$\theta = \cos^{-1} \lambda$</td>
</tr>
<tr>
<td>17</td>
<td>$V' = 4.44\phi fN$</td>
<td>$\frac{V_1}{V_2} = \frac{N_1}{N_2}$</td>
<td>$\frac{I_2}{I_1} = \frac{N_1}{N_2}$</td>
<td>$V_{\text{reg}}% = \left( \frac{V_{NL} - V_{FL}}{V_{FL}} \right) \times 100$</td>
<td>$T = k\phi I_a$</td>
</tr>
<tr>
<td>18</td>
<td>$N_{\text{syn}} = \frac{120f}{P}$</td>
<td>$f_r = \frac{S% \times f}{100}$</td>
<td>$S% = \left( \frac{n_{\text{syn}} - n}{n_{\text{syn}}} \right) \times 100$</td>
<td>$V_{\text{reg}}% = \left( \frac{V_{NL} - V_{FL}}{V_{NL}} \right) \times 100$</td>
<td>$T = k\phi I_a$</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td></td>
<td></td>
<td>$P = \frac{2\pi nT}{60}$</td>
<td>$\eta% = \frac{\text{output}}{\text{input}} \times 100$</td>
<td>$T = k\phi I_a$</td>
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**Stage 2a:** This list does not contain all equations in the course and transposition may be required.

**Stage 1:** Equations are also used during stage 2

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<tr>
<td>21</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>22</td>
<td>( V_T = E_0 - (I R_i) )</td>
<td>( E = \frac{F}{A} )</td>
<td>( E = \frac{I}{d^2} )</td>
<td>( E = \frac{I}{d^2} \times \cos \theta )</td>
<td>( \eta = \frac{F}{P} )</td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>( Q_c = P(\tan \theta_1 - \tan \theta_2) )</td>
<td>( X_c = R(\tan \theta_1 - \tan \theta_2) )</td>
<td></td>
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<td>24</td>
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**Stage 3:** This list does not contain all equations in the course and transposition may be required.

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</thead>
<tbody>
<tr>
<td>25</td>
<td>( V_p Y = 57.7%V_p \Delta )</td>
<td>( I_p Y = 57.7%I_p \Delta )</td>
<td>( I_{\text{motor st}} = \left(\frac{%\text{TAP}}{100}\right) \times I_{\text{DOL}} )</td>
<td>( I_{\text{line st}} = \left(\frac{%\text{TAP}}{100}\right)^2 \times I_{\text{DOL}} )</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>( I_{ST} = \frac{1}{3} \times I_{\text{DOL}} )</td>
<td>( T_{ST} = \frac{1}{3} \times T_{\text{DOL}} )</td>
<td>( V_{st} = \left(\frac{%\text{TAP}}{100}\right) \times V_{\text{DOL}} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>( I_{ST} = \left(\frac{V_{st}}{V}\right) \times I_{\text{DOL}} )</td>
<td>( T_{ST} = \left(\frac{V_{st}}{V}\right)^2 \times T_{\text{DOL}} )</td>
<td>( \text{Constant} = \frac{V}{f} )</td>
<td></td>
<td></td>
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<tr>
<td>28</td>
<td></td>
<td></td>
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</table>
Work Performance Evidence (WPE)

IMPORTANT:

Students should bring this to the attention of their employers as soon as possible.

Work Performance Evidence is required to be collected for each unit of study. This evidence is used to help measure the effectiveness of your learning and to demonstrate that the required work related practical skills have been obtained and used to consolidate the academic component of your study. That is, you possess both the theory knowledge AND practical ability to complete a task to a competent level.

For some units of study, your class teacher will collect this evidence on your behalf by setting tasks that realistically ‘simulate’ the workplace environment. The college will record and store this information. You should confirm with your class teacher at the commencement of each new unit of study whether he or she is going to collect work performance evidence on your behalf.

However, for the most part, YOU will be required to collect the evidence that demonstrates your progress in the workplace and that the required electro-technology skills are being achieved.

The electrical trades section of Miller TAFE has set-up on your behalf a ‘Skills-Tracker’ online portfolio account for you to collect and record all of your workplace learning. In due time, you will be given instruction and tuition on the use of the Skills-Tracker portfolio system.

In the meantime, log onto www.skills-tracker.com and have a look at the ‘learner guides’ and ‘supervisor guides’ found in the ‘downloads’ tab of the navigation bar.

Skills-Tracker
www.skills-tracker.com

Email: info@skills-tracker.com
Phone: +612 9543 1100

Miller student access information:
LOGIN: your student number.
PASSWORD: your surname (in lower case letters).

Note: Units that require you to collect WPE by the Skills-tracker portfolio will show a NC (Not Yet Competent) result on your transcript until your portfolio is complete and verified by the college. This will be the case even if you have passed all of your in class assessments. In most cases, the NC result will not be updated to a unit pass result of AC (Achieved Competence) until your work evidence portfolio is checked and verified toward the end of your course / apprenticeship.

***** REMEMBER *****

YOU are responsible for collecting your own workplace evidence
Unit Guide – Summary

FULL unit guides can be accessed online at www.training.gov.au
The following information is summarised and is intended to provide a broad overview only.

**Unit:**
UEENEEG106A Terminate cables, cords and accessories for low voltage circuits

**Unit Descriptor**
This unit covers the termination of cables and cords and their conductors at accessories and current-using devices designed to operate at voltages up to 1,000 V a.c. or 1,500 V d.c. It encompasses working safely and to standards, understanding wiring system and cable types and applications, selecting appropriate termination accessories, preparing and terminating cables and cords, terminating cables/cord conductors and ensuring completed termination complies with requirements.

**Pre-Requisites**
Pre-requisites are units of study that must be completed prior to commencing a new unit of study. That is, you must pass subject ‘X’ before you are allowed to commence subject ‘Y’. In some instances, pre-requisite units may be studied concurrently with new units of study.

Pre-requisites for this unit of study are:

- UEENEEE101A Apply Occupational Health and Safety regulations, codes and practices in the workplace
- UEENEEE102A Fabricate, dismantle, assemble of electrotechnology components
- UEENEEE105A Fix and secure electrotechnology equipment
- UEENEEE107A Use drawings, diagrams, schedules, standards, codes and specifications
Unit Guide – Summary continued

**Literacy and numeracy skills indicators for this unit – NRS Level 4:**

Participants are best equipped to achieve competency in this unit if they have reading, writing and numeracy skills at a level indicated by the following NRS levels.

The National Reporting System (NRS) is a nationally recognised mechanism for determining adult English language, literacy and numeracy levels.

In context for this unit of study these Indicators of Competence (IoC) are not an assessment system, but merely a guide to the specific reading writing and numeracy levels for this unit.

Further information pertaining to the description of each scale is given in Volume 2, Part 3 ‘Literacy and Numeracy’, of the UEE11 training package, available at http://training.gov.au

<table>
<thead>
<tr>
<th>Skill</th>
<th>IoC</th>
<th>Indicator of Competence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 4</td>
<td>4.1</td>
<td>Reads and interprets structurally intricate texts in chosen fields of knowledge which require integration of several pieces of information for generating meaning.</td>
</tr>
<tr>
<td></td>
<td>4.2</td>
<td>Interprets texts, which include ambiguity, and inexplicitness where reader needs to distinguish fact from opinion and infer purpose.</td>
</tr>
<tr>
<td></td>
<td>4.3</td>
<td>Interprets and extrapolates from texts containing data which includes some abstraction, symbolism, and technicality presented in graphic, diagrammatic, formatted or visual form.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Writing:</strong></td>
<td>4.4</td>
<td>Communicates complex relationships between ideas by matching style of writing to purpose and audience.</td>
</tr>
<tr>
<td>Level 4</td>
<td>4.5</td>
<td>Generates written texts reflecting a range of genres and using appropriate structure and layout.</td>
</tr>
<tr>
<td><strong>Numeracy:</strong></td>
<td>4.10</td>
<td>Selects and investigates appropriate mathematical information and relationships embedded in an activity, item or text.</td>
</tr>
<tr>
<td>Level 4</td>
<td>4.11</td>
<td>Selects and applies an expanding range of mathematical strategies flexibly to solve problems in a variety of contexts.</td>
</tr>
<tr>
<td></td>
<td>4.12</td>
<td>Examines and questions the appropriateness, possible interpretations and implications of aspects of a mathematical activity.</td>
</tr>
<tr>
<td></td>
<td>4.13</td>
<td>Uses a range of oral and written informal and formal language and representation including symbols, diagrams and charts to communicate mathematically.</td>
</tr>
</tbody>
</table>
Unit Guide – Assessment

Student Assessment Guidelines – (SAG’s)

Assessment is an important part of learning at TAFE NSW.

TAFE NSW provides comprehensive information for students regarding assessment. A copy of ‘Every Student’s Guide to Assessment in TAFE NSW’ can be obtained by visiting:


The following information provided in this workbook is to assist you in your understanding of the assessment process, by providing an overview of assessment for this unit. Any questions regarding assessment can be addressed by your class teacher.

Course: National Course Code: UEE30811

Qualification and name: Certificate III in Electrotechnology Electrician

TAFE NSW course number: 20222. Version: 1

Requirements to receive the qualification:

To achieve UEE30811 Certificate III in Electrotechnology, learners are required to complete all units from the core and elective units to a weight of 140 points. Core and elective units are shown in the ‘Course Outline’ contained in the preceding pages of this workbook.

Recognition: If you have completed other relevant training you may be eligible to have units of competency from previous training counted towards completion for this course. Talk to your teacher or head teacher if you think you may be eligible for recognition for units previously completed.

Learner Support: Students who require support to meet their learning goals should discuss their options by talking to their teacher or Teacher/Consultant for students with a disability.

Assessment Results: Results will be made available to you by your class teacher after each assessment event. Results may also be viewed online (final unit results only) by visiting TAFE ‘eServices’. See the ‘Useful Links’ on the ‘student contacts’ page in the front of this workbook for further information on TAFE eServices. Concerns you may have about your assessment results should be addressed to your class teacher within 3 weeks of receiving a result.
Meeting Competency Requirements:

In order to be deemed ‘competent’ in a unit of study, you will be required to achieve a minimum Knowledge and Skills (KS) percentile mark AND satisfactorily complete the Work Performance Evidence (WPE) requirements (ie: Skills-tracker or in-class evidence collected by your teacher). In all other cases participants will be deemed as ‘not yet competent’ (NC).

Units in this course are ungraded. Your TAFE transcript will record your result as follows:

- **AC** - A Unit result code of AC (achieve competency) will be issued if all associated KS specification(s) and work performance evidence have been passed and/or completed.
- **NC** - A Unit result code of NC (not yet competent) will be issued if either the KS specification or work performance evidence has not been passed and/or completed.

Note: Units that require you to collect WPE by the Skills-tracker portfolio will show a NC result on your transcript until your portfolio is complete and verified by the college. In most cases this will not be done until you approach the end of your course / apprenticeship.

Assessment Events:

Assessment events are varying methods of assessment used to collect information and measure an individual’s level of learning. Below is a table listing typical event methods.

<table>
<thead>
<tr>
<th>Assessment Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quizzes:</td>
<td>May consist of multiple choice questions, short answer questions, descriptive questions, calculations and diagram completion questions</td>
</tr>
<tr>
<td>Tutorial:</td>
<td>May consist of section review questions, projects, class assignments, research etc.</td>
</tr>
<tr>
<td>Skills Practice:</td>
<td>May consist of diagram completion questions, circuit and component connections, motor connections, cabling connections, safe isolation procedures, meter and test equipment connections and measurements and the like</td>
</tr>
<tr>
<td>Practical Exam:</td>
<td>May consist of diagram completion questions, circuit and component connections, motor connections, cabling connections, safe isolation procedures, meter and test equipment connections and measurements and the like</td>
</tr>
<tr>
<td>Theory Exam:</td>
<td>May consist of multiple choice questions, short answer questions, descriptive questions, calculations and diagram completion questions</td>
</tr>
<tr>
<td>Work Performance Evidence:</td>
<td>May consist of actual workplace evidence collected and recorded by profiling (eg: skill-tracker) or simulated workplace evidence collected in the classroom by your teacher or a combination of both</td>
</tr>
</tbody>
</table>

Assessment events used in this particular unit of study are ‘weighted’ and shown on the following page.
Unit Guide – Assessment

**Required skills and knowledge**

This describes the essential skills and knowledge and their level, required for this unit.

Evidence shall show that knowledge has been acquired of safe working practices, rationale and solving problems in the relevant unit. The knowledge and skills shall be contextualised to current industry standards, technologies and practices.

*View the section title page in your class workbook or the complete unit guide for a full list of the fundamentals covered by each topic within this unit.*

Below is a list indicating the content areas to be covered by the required skills and knowledge specification for this unit:

**Note:** Topics may not be delivered in the order indicated by the full unit guide.

Additional information pertinent to your learning may also be included during unit delivery.

**KS01-EG106A - Wiring systems types, application and terminations**

<table>
<thead>
<tr>
<th>WORKBOOK SECTION NUMBER</th>
<th>CONTENT</th>
<th>TOPIC NUMBER AS LISTED IN THE FULL UNIT GUIDE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1</td>
<td>Cable types and terminations</td>
<td>T1</td>
</tr>
<tr>
<td>Section 2</td>
<td>Cords, cables and plugs</td>
<td>T2</td>
</tr>
<tr>
<td>Section 3</td>
<td>Flat TPS wiring systems</td>
<td>T3</td>
</tr>
<tr>
<td>Section 4</td>
<td>Circular TPS wiring systems</td>
<td>T4</td>
</tr>
<tr>
<td>Section 5</td>
<td>Thermoplastic insulated cables in non-metallic enclosures</td>
<td>T5</td>
</tr>
<tr>
<td>Section 6</td>
<td>Thermoplastic insulated cables in metallic enclosures</td>
<td>T6</td>
</tr>
<tr>
<td>Section 7</td>
<td>Fire protection cabling and systems</td>
<td>T7</td>
</tr>
<tr>
<td>Section 8</td>
<td>Steel wire armoured (SWA) cables</td>
<td>T8</td>
</tr>
<tr>
<td>Section 9</td>
<td>Trailing cables and catenary systems</td>
<td>T9</td>
</tr>
</tbody>
</table>
Unit Guide – Assessment

**Student Assessment Guide for this unit:**

Evidence for competence in this unit shall be considered holistically. The required skills and knowledge relating to this unit will be assessed in following manner:

<table>
<thead>
<tr>
<th>Event #</th>
<th>Event Name / Timing / Duration</th>
<th>Evidence Method</th>
<th>Wgt.</th>
<th>Out Of %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Quiz - Weekly</td>
<td>Formative Assessment</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Tutorial / Project Work - Weekly</td>
<td>Formative Assessment</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>Skills Practice - Weekly</td>
<td>Formative Assessment</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Theory Exam 1 - After Section 9 - 2 Hrs - MUST PASS 60%</td>
<td>Summative Assessment</td>
<td>30</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>Work Performance Evidence (Pass / Fail)</td>
<td>Profiling / Skills Tracker</td>
<td>P/F</td>
<td></td>
</tr>
</tbody>
</table>

* ALL 'MUST PASS' events must be passed AND Total Cumulative KS mark must be 60% or greater

* Work Performance Evidence (WPE) has been reviewed and satisfies requirements (Pass / Fail)

* Final Competency Result (AC) Achieved competency OR (NC) Not Yet Competent. See note below.

**Note:** Only award AC if ALL "MUST PASS' events are passed, KS mark 60% or greater AND WPE is Passed
Unit Guide – Assessment

**Absence from a class assessment:**

All students are expected to sit class assessments at the normal scheduled time.

If due to ill health or other unforeseen and acceptable circumstances you are not able to attend a scheduled class test, it is **your responsibility** to make contact with your class teacher or the section head teacher and inform them of your reason for missing the assessment.

**NOTE:** This contact must be made, prior to, but certainly no later than 24 hours after the scheduled assessment.

Failure to contact the class teacher or section head teacher within the specified time will be taken as your withdrawal from the assessment and a **zero mark** will be recorded.

‘Schoolies’ is not an acceptable reason to miss an assessment. Zero marks will be recorded.

Your Class Teachers Name: ________________________________
Your Class Teachers Phone No: ________________________________
Or Head Teachers No: 9825-7398 or 9825-7389  Fax No: 9825-7470

**Workplace Health and Safety (WHS):**

The laws protecting the Health and Safety of people at work apply to students who attend TAFE Colleges, either part time or full time. These laws emphasise the need to take reasonable steps to eliminate or control risk at work (this includes a TAFE College). TAFE NSW has the responsibility for the control, and where possible, the elimination of health and safety risk at the college. This includes bullying and harassment. You are encouraged to help in eliminating hazards by reporting to your teacher or other College staff, anything that you think may be a risk to you or other people.

Your teacher will encourage you to assist in hazard identification and elimination, and to devise control measures for any risks to yourself and other people that may arise during practical exercises. The WHS Act 2011 requires that teachers and students take reasonable steps to control and monitor risk in the classroom, workshop or workplace.

*Individuals failing to observe and follow ALL Workplace Health and Safety requirements in any part of the college, not limited to but including, hall-ways, class rooms, laboratories, wiring rooms and workshops will be promptly removed for their own safety and for the safety of others. Breaches will be recorded on your TAFE record.*
CABLE TYPES & TERMINATIONS

PURPOSE:
In this section you will develop your knowledge in the construction, specifications, colour coding and application of cords, power, signal, and communication cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:
At the end of this section the student will be able to:

- List common cables and state typical applications
- Explain the terms conductor material, stranding, insulation type, voltage rating, screening, sheathing, armour and serving
- State the Australian and International colour standards for cords and cables
- Describe the construction of common cables
- Identify cords and cables by conductor size, type and rating
- Describe typical applications for given cord and cable types
- Identify hardware used in terminating cords and cables
- Demonstrate correct preparation for termination of cords and cables
- Correctly terminate cords and cables using crimp lugs, tunnel connections, soldering and solderless lugs.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, *Electrotechnology Practice 2nd ed.*, Section 10 pages 295 -319, Pearson Education Australia. French’s Forest NSW 2086
1. CONDUCTORS

Conductors are defined as materials that easily allow the flow of _________.
Metals are _______ conductors while insulators are _______.

The 2 common metals used for conductors in the electrical trade are:
_____________ and ________________.

Aluminium has become more prevalent for larger C.S.A. conductors as it is
cheaper and lighter but more brittle than copper.

2. CABLES

When a conductor is insulated it is called a cable. Cables can be: single
core TPI, SDI, Twin, Twin and Earth, multicore and many other
combinations.

*See pictures on page 307 of your textbook or look at cable samples
provided by your teacher.
### 3. TYPES OF CABLES USED IN ELECTRICAL AND COMMUNICATIONS WORK

#### Student exercise 1

Using your textbook and the cable samples provided, fill in the details for the cables listed in the table below.

<table>
<thead>
<tr>
<th>LOW VOLTAGE POWER CABLES</th>
<th>Application</th>
<th>Special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TPI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flat TPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circular TPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWA cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIMS cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radox cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass fibre cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V105 cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible cord</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXTRA-LOW VOLTAGE CABLES (DATA, TELEPHONE, ETC)</th>
<th>Application</th>
<th>Special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-axial cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fibre optic cables</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. CABLE TERMS.

- **Stranding:** The _______________ and _______________ of the wires used to make the core of the conductor:

  Conductors used for electrical wiring can be single core or stranded. Most conductors used for electrical wiring are stranded copper which has been annealed to make it more flexible. *See Figure 10.2 on Page 296 of your textbook.*

- **Insulation:** Conductors used for aerials are often ‘bare’ or un-insulated but most conductors used for wiring systems are insulated. Common insulation materials are: Thermoplastic (PVC) and Cross linked Polyethylene (XLPE). *See types of insulation on page 304 of your textbook.*

- **Screening:** This cable has a light weight metal layer which is not for mechanical protection but for ________________ - ________________ protection if earthed correctly.

  Screening on electrical cables is designed to stop the magnetic field surrounding a conductor or cable interfering with signal conductors which are installed near the power cables. Screens can be either ‘foil wrapped’, ‘braided’ or ‘spiral' wound. *See Figure 10.34 on Page 313 of your textbook.*

- **Voltage rating:** This states the operating voltage that the cable can handle between cores i.e. 1kV/600V means 1000V between live conductor and earth, and the 600V means between live cores.

- **Temperature rating:** This is the ________________ temperature the cable can operate up to. V75, V90, V105 are examples of available insulation temperature ratings for PVC (Poly Vinyl Chloride) insulation. The number after the prefix refers to the maximum cable operating temperature permissible.
5. PROTECTING CABLES AGAINST THE ELEMENTS.

- **Armour:** Cable armour protects cables against mechanical damage. Steel wire armoured (SWA) cables are often used in factories and mines where machinery could damage cables if they didn’t have extra mechanical protection.

  See Figure 10.38 and 10.39 on Page 314 of your textbook.

- **Sheathing:** This is an extra layer of electrical insulation which also gives some mechanical protection.

  A sheath is a protective outer covering used to provide electrical cables with extra insulation, protection against mechanical damage or damage from chemicals, heat, fire and other sources. See Figure 10.30-10.38 on Page 310-314 of your textbook.

- **Serving:** This is a layer of electrical insulation on the very outside of the cable, it can also act a __________________ barrier.

  Serving is a protective layer on the outside of a cable and is used to protect cables from mechanical, chemical and water damage. It is often used with armour and sheathing and can also be used an extra layer of insulation.

  See Figure 10.30 on Page 310 of your textbook.

6. REQUIREMENTS TO PROTECT AND SUPPORT CABLES ADEQUATELY

Cables must be protected against mechanical damage, from heat and fire, from corrosion and in some cases from the effects of magnetic fields. See Pages 324 to 364 of your textbook for details. Cable protection will be discussed in detail later in this unit.
7. AUSTRALIAN AND INTERNATIONAL COLOUR STANDARDS FOR CORDS AND CABLES

Student Exercise 2
Using Figure 3.1 & 3.2 in AS3000:2007 fill in the table below for Single phase power cables;

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Acceptable Colours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current AS/NZS and European standard</td>
</tr>
<tr>
<td></td>
<td>Superseded AS/NZS standard</td>
</tr>
<tr>
<td>Earthing/Bonding</td>
<td></td>
</tr>
<tr>
<td>Active</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
</tr>
</tbody>
</table>

Student Exercise 3
Using Figure 3.1 & 3.2 in AS3000:2007 fill in the table below for Three phase power cables;

<table>
<thead>
<tr>
<th>Conductor</th>
<th>Acceptable Colours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current AS/NZS and European standard</td>
</tr>
<tr>
<td></td>
<td>Superseded AS/NZS standard</td>
</tr>
<tr>
<td>Active 1 (A phase)</td>
<td></td>
</tr>
<tr>
<td>Active 2 (B phase)</td>
<td></td>
</tr>
<tr>
<td>Active 3 (C phase)</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td></td>
</tr>
<tr>
<td>Earth</td>
<td></td>
</tr>
</tbody>
</table>
8. FLEXIBLE CORDS

A flexible cord is a cable whose conductors have many strands of fine wire which makes the cable more flexible. Cords are used to supply appliances like kettles, toasters and electronic equipment. AS 3000 defines a cord as:

*See samples provided by your teacher or pictures on page 297,398 in your textbook

9. C.S.A. AND NUMBER OF CORES

Single strand conductors have limited ________________ as their size increases. Stranding of cable makes it more flexible. This is important for extension cords because they are often moving while in use, but it is equally important for permanent installations. A certain amount of flexibility allows the cable to be “____________ _____” more easily.

Typically, permanent power cable has seven strands

- Stranding code: e.g. 7/0.67 = 7 strands, with each strand 0.67mm Ø

1 mm² cable  
1.5 mm² cable.  
2.5 mm² cable. 

Solid core - 1/1.13  
Stranded - 7/0.5  
Stranded - 7/0.67

\[
\Lambda = \frac{\pi d^2}{4}
\]

\[
\Lambda = \frac{\pi \times 1.13^2}{4} = \frac{\pi \times 0.5^2}{4} = \frac{\pi \times 0.67^2}{4}
\]

= 1.00 mm²  
= 1.37 mm²  
= 2.47 mm²

Typical comparative sizes of cable used for domestic installations:

- 1 mm² or 1.5 mm² for lighting circuits.
- 2.5mm² for power circuits.
- 4 mm² or 6 mm² for ovens and cooktops.
10. CABLE CLASSIFICATION
Cables are generally classified in terms of:
- Conductor cross sectional area (c.s.a.); and
- The number of cores contained in the sheath; and
- Type of insulation or sheath
Markings on the cable and on the cable drum help identify the cable. See examples provided by your teacher.

11. ELECTRICAL CONNECTIONS (CLAUSE 3.7)
Clause 3.7.1 - Connections between conductors and other electrical equipment shall provide electrical continuity, an appropriate level of insulation and adequate mechanical strength.

There are two broad categories of connection methods:
1. Fusion: soldering, welding and brazing.
2. Pressure: clamping, compression
These methods cannot be used together. That is, two conductors can not be soldered together and then compressed in a crimp connector, or terminated into the terminal of a switch, socket-outlet or circuit breaker etc.

**Soldered Connection technique**
*See soldering Video and discuss*
Pressure Connections:
These connections are reliable, convenient and economical.

1. Screw connections
Terminating copper conductors in screw type connectors (BP, Blue Point or Tunnel connectors and appliance and accessory terminals)
Single core conductors up to 2.5 mm² are ________________ over when terminated singly.
This provides a sufficiently adequate seating surface for the terminator screw.
If not doubled over the conductor could ride up beside the screw, becoming weakened and break.
Stranded conductors or a number of single core conductors that are to be terminated should be ________________ together.

Tunnel and BP connectors
2. Crimp connections
   
   See Pages 299 of your textbook

12. PREPARING A CONDUCTOR FOR TERMINATION OR CONNECTION

When preparing stranded conductors for termination or connection the following points should be observed:

1. TPS cable should not have any more than ________mm of sheathing removed.
2. The conductor insulation should be removed without causing damage to the conductor, either by “nicking” the copper or removing strands. Either of these two faults will reduce the current carrying capacity of the conductor.
   
   They are illustrated in the photographs.

- Strands nicked
- Missing strands
- Well stripped
3. When stripped, stranded conductors should be twisted in the direction of the twist of the strands in order to help prevent the escape or spreading of individual strands.

Ensure the twist is not too tight as this will stretch the strands and reduce their current carrying capacity as well as make them work harden.

*The top sample is twisted correctly, the bottom sample is too tight.*
CABLE TYPES & TERMINATIONS

PURPOSE:

In this section you will develop your knowledge in the construction, specifications, colour coding and application of cords, power, signal, and communication cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this practical assignment the student will be able to:

• Describe the construction of common cables
• Identify cords and cables by conductor size, type and rating
• Identify hardware used in terminating cords and cables
• Demonstrate correct preparation for termination of cords and cables
• Correctly terminate cords and cables using crimp lugs, tunnel connections, soldering and solderless lugs.

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

• AS/NZS 3000:2007
• Hampson, Jeffery, Electrotechnology Practice 2nd ed., Section 10 pages 295 -319, Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students on an individual basis.
PROCEDURE 1

Prepare a cable sample card consisting of samples of cable, as indicated below, which are to be cut to length and fitted to this sheet.

1. Attach this sheet to the timber panel at the rear of the wiring cubicle
2. Strip 25mm of insulation off each cable.
3. Twist the strands of the stranded conductor
4. For conductors up to and including 2.5mm$^2$ double the conductor over so it is ready to terminate
5. Attach each cable to the sheet using cable clips or / pin-clips
Attach the samples with assorted cable clips provided by your teacher.

### Cable sample type

| Single insulation |  |
|--------------------|--
| Strip 1 mm² solid core TPI cable – 1/1.13 (with Pliers) | Strip 25 mm (page not to scale) |
| Strip 2.5 mm² stranded TPI cable – 7/0.67 (with Pliers) | Strip 25 mm |
| Strip 4 mm² stranded TPI cable – 7/0.85 (with Pliers) | Strip 25 mm |
| Strip 6 mm² stranded TPI cable – 7/1.04 (with Knife) | Strip 25 mm |
| Strip 2.5 mm² earth cable – 7/0.67 (with wire stripper) | Strip 25 mm |
| Strip 4 mm² stranded earth cable – 7/0.85 (with Knife) | Strip 25 mm |
Attach the samples with assorted cable clips provided by your teacher.

<table>
<thead>
<tr>
<th>Cable sample type</th>
<th>Double insulation</th>
<th>Single insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip 1mm² single core double insulated (SDI) with Pliers</td>
<td>Remove 25 mm of double insulation</td>
<td>Strip 25 mm (page not to scale)</td>
</tr>
<tr>
<td>Strip 1.5 mm² single core double insulated (SDI) with wire strippers</td>
<td>Remove 25 mm of double insulation</td>
<td>Strip 25 mm</td>
</tr>
<tr>
<td>Strip 1 mm² two core flat (twin) with pliers</td>
<td>Remove 25 mm of double insulation</td>
<td>Strip 25 mm</td>
</tr>
<tr>
<td>Strip 1.5 mm² two core flat (twin) with wire strippers</td>
<td>Remove 25 mm of double insulation</td>
<td>Strip 25 mm</td>
</tr>
<tr>
<td>Strip 2.5 mm² two core &amp; earth (Twin &amp; earth) with pliers</td>
<td>Remove 25 mm of double insulation</td>
<td>Strip 25 mm</td>
</tr>
</tbody>
</table>
ALTERNATIVE PROCEDURE 1

1. TERMINATING SINGLE INSULATED CABLES

Cut 300 mm of each conductor 1 mm², 2.5 mm², 4 mm², 6 mm²

Strip the end of the cable and fold the conductor over

2. JOINING CABLES IN A SINGLE CONNECTOR

Cut two 200 mm of each conductor 1 mm², 2.5 mm², 4 mm², 6 mm²

Strip one end of the cable and join in a single connector

PROCEDURE 2

1. Connect various cables to a main earth cable as shown in the diagram below.
2. Using the information given in the diagram and the table to complete the connections.
3. All cable is to be insulated earth cable with sizes as indicated
4. Joints A, B, C and D are spaced 100 mm apart,
5. Joint E is 50 mm from D.
6. The short lengths of cable are approximately 150 mm long.
<table>
<thead>
<tr>
<th>Connection</th>
<th>Cable Size</th>
<th>Jointing to 6mm² cable</th>
<th>Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>6mm²</td>
<td>Two screw tunnel connector</td>
<td>Non-insulated crimp lug</td>
</tr>
<tr>
<td>B</td>
<td>1.5mm²</td>
<td>Soldered (use soldering iron)</td>
<td>Non-insulated crimp lug</td>
</tr>
<tr>
<td>C</td>
<td>2.5mm² 4mm²</td>
<td>Line tap</td>
<td>Insulated crimp lugs</td>
</tr>
<tr>
<td>D</td>
<td>2.5mm² 2.5mm² 4mm²</td>
<td>Wrapped, soldered joint. (Use propane torch)</td>
<td>Solderless Lugs 2.5 mm (Ross Courtney) 2.5 mm Stanco 4.0 mm (Ross Courtney)</td>
</tr>
<tr>
<td>E</td>
<td>6mm²</td>
<td>Joining two 6 mm² cables with 6 mm crimp link</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>6mm²</td>
<td>Joining two 6 mm² cables with a bound, soldered joint (Use propane torch)</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>6mm²</td>
<td>Connection to 12 mm earth stake with an earth clip</td>
<td></td>
</tr>
</tbody>
</table>
Notes
*****
CABLE TYPES & TERMINATIONS

1. Name 2 advantages of stranded conductor over single core solid conductor?

_________________________________________________________________
_________________________________________________________________

2. What is meant by the term *temperature rating*?

_________________________________________________________________
_________________________________________________________________

3. What is the purpose of *serving* on a cable?

_________________________________________________________________
_________________________________________________________________

4. Why, if possible do we double over the ends of a conductor before it is inserted into a tunnel type connector?

_________________________________________________________________
_________________________________________________________________

5. *Answer review questions 1, 4, 6, 9 and 13 on page 303 in your textbook.*

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
CABLES CORDS & PLUGS

PURPOSE:

In this section you will develop knowledge and skills required to select, assemble and connect cords and plugs for voltages up to 500V.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Select appropriate flexible cords for given applications
- Prepare cord ends for connection
- Fit a standard 3 pin plug top to a flexible cord
- Fit a standard three pin extension socket to a flexible cord
- Connect a variety of plugs to different flexible cord types
- State the requirements of AS/NZS 3000 for flexible cords, cables and plugs.
- Use basic test equipment to test and locate various faults in flexible cords and cables

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 320-323, Pearson Education Australia. French’s Forest NSW 2086
- Safe work Australia, Electrical practices for construction work (2007)
1. INTRODUCTION

Flexible cords (and plugs) provide a safe and convenient method of connecting appliances and electrical equipment to the supply. However flexible cords can be the weakest link, in both safety and reliability, if installed or used inappropriately.

How is a flexible cord different from other cables?

AS/NZS 3000 defines a flexible cable as:

Clause 1.4.20

AS/NZS 3000 also defines a flexible cord as:

Clause 1.4.36

• The conductors in a flexible cord are made up of many more strands of finer wire than an ordinary cable. This allows the cord to flex without breaking the conductors.

• Special cables which are constructed to afford flexibility similar to that of a cord and which have conductors greater than 4mm² or more than five cores are known simply as ________________________.

Examples of this are: the cable from a welding machine to the welding electrode holder, the cable connected to the pendant control for a hoist.
2. SELECTING THE APPROPRIATE CORD

The points that must be considered when selecting a cord for a particular application are the:

- Current the cord is expected to carry.
- Number of cores.
- Conditions under which the cord is to be used.

Flexible cords must have the capacity to carry a current not less than the rating of the ____________ to which they are connected.

A guide to selecting the correct conductor size in flexible cords from AS 3008 Table 16 is shown below:

<table>
<thead>
<tr>
<th>Current rating of appliance (amps)</th>
<th>Number and diameter of wires (mm)</th>
<th>Nominal area of conductor (mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>16 / 0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>7.5</td>
<td>24 / 0.2</td>
<td>0.75</td>
</tr>
<tr>
<td>10</td>
<td>32 / 0.2</td>
<td>1.0</td>
</tr>
<tr>
<td>16</td>
<td>30 / 0.25</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>50 / 0.25</td>
<td>2.5</td>
</tr>
<tr>
<td>25</td>
<td>56 / 0.3</td>
<td>4.0</td>
</tr>
</tbody>
</table>

The most common flexible cords are insulated and sheathed with Elastomer or PVC. Small appliances such as clothes irons and toasters have cords with an overall textile braiding. There are other special types of flexible cords such as one that has a metallic screening between the sheathing and the cores.
The table below can be used as a guide in selecting flexible cords.

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Conductor size (CSA)</th>
<th>Approved Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel two core – unsheathed</td>
<td>0.5mm²</td>
<td>1 - Hand held double-insulated appliances rated at not more than 3A.</td>
</tr>
<tr>
<td>(known as figure 8)</td>
<td>0.75mm²</td>
<td>2 - Double insulated appliance where the cord is not used roughly. Not permitted in the vicinity of dampness.</td>
</tr>
<tr>
<td>Light duty - sheathed</td>
<td>min 0.75mm²</td>
<td>3 - As (2) and non-double-insulated appliances where the cord is not used roughly. Can be used in the vicinity of dampness.</td>
</tr>
<tr>
<td>Ordinary duty - sheathed</td>
<td>min 0.75mm²</td>
<td>4 - Appliances that are not double insulated where the cord may be used roughly. Can be used in the vicinity of dampness. Flexible cord extensions.</td>
</tr>
<tr>
<td>Heavy duty – sheathed</td>
<td>min 0.75mm²</td>
<td>5 – as (4)</td>
</tr>
<tr>
<td>Textile braided overall</td>
<td>min 0.75mm²</td>
<td>6 – as (3) but not permitted in the vicinity of dampness.</td>
</tr>
</tbody>
</table>

3. WORKING WITH FLEXIBLE CORDS AND PLUGS - COLOUR CODING

Each terminal of a plug top, extension socket or appliance is intended to be connected to a particular conductor; that is the active conductor, the neutral conductor and the earthing conductor. To make this easy and to help avoid mistakes, flexible cords are colour coded to an international standard. This also makes visual checking easy. The colour code recommended by the standard is:

Active -  
Neutral-  
Earth -  
This code should be adhered to whenever the flexible cord has the individual cores coloured in this way. Some flexible cords are manufactured with red and black cores. In this case, the conventional arrangement for the colour code is:

- Active
- Neutral
- Earth

\[ \text{NOW OBSELETE IN AUSTRALIA} \]
\[ \text{BUT SOME STILL IN SERVICE} \]

Cables coloured green, or green/yellow must be used only as earthing conductors.

4. SECURING THE CORD

Flexible cords must be fitted to devices so that any pull on the cord does not exert any strain on the terminal connections. This is usually done by a ‘tortuous path’ that the cord or cores must follow to the terminals in the device to be connected. The strain of pulling on the cord is taken up in the curves formed in the cord path and not the terminals. Another method is by a. ______________________________

All of these methods are generally built into the device intended to be cord connected.
5. EARTHING

- Some appliances are made with an outer casing of electrical insulating material. They are constructed in a special way that provides a double layer of insulation between ‘live’ electrical parts and those parts that can be touched when the appliance is plugged in ready for normal use. These appliances are marked with the international symbol for **Double Insulated** and **must not be earthed**

- Appliances not classified as double insulated **must be earthed** and are provided with a terminal specifically for this purpose. The earthing system, (that is conductors and connections), must have a _______ resistance to ensure the fuse or circuit breaker protecting the appliance circuit ________ quickly in the event of a fault.

To ensure the earthing connection has an extremely low resistance the following points should be observed.

- Fit earthing conductors with the appropriate terminal device (crimp lug, “Ross Courtney” etc.) where clamping terminals are not provided.
- Make sure the earthing conductor is in contact with the clean bare metal of the appliance enclosure or connected to a terminal that is.
- Make sure the earth screw tightly clamps the earthing connections.
- Protect earthing connections exposed to corrosion by painting with an exterior grade paint to exclude moisture.
7. **CABLES, CORDS AND PLUGS USED FOR CONSTRUCTION**

There are specific regulations with respect to cords and plugs used on-site in the construction industry. See clause 7, *Electrical practices for construction work (2007).* Code of practice for more detail.


8. **PLUGS AND SOCKETS**

There are many types of plug tops, the most common being the 10 A three-pin plug.

This plug top has three flat pins, active pin, neutral pin and the largest/longest pin, the earth. The earth pin is usually plated to reduce contact resistance.

![Diagram of plug top with labels: Neutral - blue, Active - brown, Earth - green/yellow]

The plug is suitable for cord-connected appliances rated at not more than ______ amps and intended for supply from a standard socket outlet. An older term was general-purpose outlet (GPO) or the common term power point.

Factors that determine the design of plugs (and sockets) are:

1. ____________
2. ____________
3. ____________
4. ____________

**Voltage and current rating:** a plug must have a voltage and current rating not less than that of the appliance it supplies, and its intended socket.
**Protection rating:** a plug must be suitable for the environment in which it is to be used. Electrical equipment including plugs and sockets are given an international protection (IP) rating, which indicates where it can be used. The IP rating indicates the level of protection against the entry of moisture and foreign bodies into a plug or socket enclosure. Plug tops typically selected for use in industry, damp areas, and construction sites would require a rating of IP56 (often referred to as hose proof). Refer to the Australian Standard AS 1939 and AS/NZS 3000:2007 (appendix G) for details of this protection rating.

The following IP tables are taken from AS/NZS 3000:2007 – Appendix G

<table>
<thead>
<tr>
<th>Code letters (international protection)</th>
<th>IP</th>
<th>2</th>
<th>S</th>
<th>C</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>First characteristic numeral (numerals 0 to 6, or letter X)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second characteristic numeral (numerals 0 to 8, or letter X)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional letter (optional) (letters A,B,C,D)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional letter (optional) (letters H,M,S,W)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

An enclosure with this designation (IP Code)

(2) – protects persons against access to hazardous parts with fingers, and
- protects the equipment inside the enclosure against ingress of solid foreign objects having a diameter of 12.5 mm and greater.

(3) – protects the equipment inside the enclosure against the harmful effects because of water sprayed against the enclosure.

(C) – protects persons handling tools having a diameter of 2.5 mm and greater and a length not exceeding 100 mm against access to hazardous parts (the tool may penetrate the enclosure up to its full length).

(H) – indicates that the equipment is high voltage apparatus.

**FIGURE G.2 EXAMPLE OF 'IP' RATING**
### First numeral table

<table>
<thead>
<tr>
<th>IP</th>
<th>Requirements</th>
<th>Example</th>
<th>Protection of persons against access to hazardous parts with</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No protection</td>
<td><img src="image1.png" alt="Image" /></td>
<td>Non-protected</td>
</tr>
<tr>
<td>1</td>
<td>Full penetration of 50 mm diameter sphere not allowed. Contact with hazardous parts not permitted</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Back of hand</td>
</tr>
<tr>
<td>2</td>
<td>Full penetration of 12.5 mm diameter sphere not allowed. The jointed test finger shall have adequate clearance from hazardous parts</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Finger</td>
</tr>
<tr>
<td>3</td>
<td>The access probe of 2.5 mm diameter shall not penetrate</td>
<td><img src="image4.png" alt="Image" /></td>
<td>Tool</td>
</tr>
<tr>
<td>4</td>
<td>The access probe of 1.0 mm diameter shall not penetrate</td>
<td><img src="image5.png" alt="Image" /></td>
<td>Wire</td>
</tr>
<tr>
<td>5</td>
<td>Limited ingress of dust permitted (no harmful deposit)</td>
<td><img src="image6.png" alt="Image" /></td>
<td>Wire</td>
</tr>
<tr>
<td>6</td>
<td>Totally protected against ingress of dust</td>
<td><img src="image7.png" alt="Image" /></td>
<td>Wire</td>
</tr>
</tbody>
</table>

**FIGURE G1 (in part) IP CODES**
Second numeral table

<table>
<thead>
<tr>
<th>IP</th>
<th>Prescriptions</th>
<th>Example</th>
<th>Protection from water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No protection</td>
<td>![image]</td>
<td>Non-protected</td>
</tr>
<tr>
<td>1</td>
<td>Protected against vertically falling drops of water. Limited ingress permitted</td>
<td>![image]</td>
<td>Vertically dripping</td>
</tr>
<tr>
<td>2</td>
<td>Protected against vertically falling drops of water with enclosure tilted 15° from the vertical. Limited ingress permitted</td>
<td>![image]</td>
<td>Dripping up to 15° from the vertical</td>
</tr>
<tr>
<td>3</td>
<td>Protected against sprays to 60° from the vertical. Limited ingress permitted</td>
<td>![image]</td>
<td>Limited spraying</td>
</tr>
<tr>
<td>4</td>
<td>Protected against water splashed from all directions. Limited ingress permitted</td>
<td>![image]</td>
<td>Splashing from all directions</td>
</tr>
<tr>
<td>5</td>
<td>Protected against jets of water. Limited ingress permitted</td>
<td>![image]</td>
<td>Hosing jets from all directions</td>
</tr>
<tr>
<td>6</td>
<td>Protected against strong jets of water. Limited ingress permitted</td>
<td>![image]</td>
<td>Strong hosing jets from all directions</td>
</tr>
<tr>
<td>7</td>
<td>Protected against the effects of immersion between 15 cm and 1 m</td>
<td>![image]</td>
<td>Temporary immersion</td>
</tr>
<tr>
<td>8</td>
<td>Protected against long periods of immersion under pressure</td>
<td>![image]</td>
<td>Continuous immersion</td>
</tr>
</tbody>
</table>

**For example** the minimum degree of protection (IP rating) for a socket outlet installed in the following conditions:

1. On the side of a building, subject to the weather is.  
   ![image] IP - 44

2. Installed in a high pressure car wash bay is.  
   ![image] IP - 56

3. Installed above normal water level, **inside** an underground raintank that may occasionally flood is.  
   ![image] IP - 67
**Pin Configuration:** Plugs and sockets are designed with various pin styles and configurations to prevent an appliance being supplied from an inappropriately rated socket outlet.

Some single-phase plug and socket configurations are shown below.

![Plug and Socket Configurations](image)

**Student exercise 1:** Answer the following questions:

1. What is the difference between a 10A 250V socket and 15A 250V socket?

   __________________________________________________________

2. What is the difference between a 10A 250V socket and 20A 250V socket?

   __________________________________________________________

3. Would a 15A 250V plug fit into a 10A 250V socket? (explain your answer)

   __________________________________________________________

4. Would a 15A 250V plug fit into a 25A 250V socket? (explain your answer)

   __________________________________________________________

5. How would the switch mechanism that controls a 10A socket vary from a switch mechanism that controls a 25A socket?

   __________________________________________________________
3 PHASE PLUG TOPS

The arrows above indicate the ‘key’ on the plug tops. The key is designed to fit into the ‘keyway’ on the corresponding socket so plug-tops cannot be rotated or inserted into an incorrectly rated socket.

Terminal wiring and test voltages for a 3 Phase Plug.

*See Figure 10.55 on page 322 of your textbook
**Student exercise 2:** Discuss and list 3 possible hazards that may occur as a result of a plug-top being rotated or inserted into the wrong socket.

1. __________________________________________________________________

2. __________________________________________________________________

3. __________________________________________________________________

Other devices commonly used in the connection of appliances and equipment by flexible cords, are the extension socket and the appliance plug. The extension socket is the socket device on an extension cord in to which a plug is inserted. Plugs and sockets installed on extension leads used in the construction industry must be either __________ or ______________.
6. **AS/NZS 3000 REQUIREMENTS**

Flexible cords, when used as extension leads, may only be joined by means of “suitable cable couplers.” (Clause 3.7.2.8(b)). Undue stress on the connections within the coupler must be avoided by means of pillars, posts, grips, tortuous path or other effective means. Knotting of the cable is not permitted.

Flexible cords may be used as installation wiring provided they are a heavy-duty sheathed type and installed in the same manner as insulated sheathed cables. (Clause 3.9.7.4)

7. **TESTING**

**Earth Continuity**

Any Class I equipment with exposed metal parts must have its protective earth checked to ensure it is continuous from the earth pin of the plug to any exposed metal. The resistance must not be greater than 1Ω. The test is called a continuity test and the test instrument utilized for the test is an ohmmeter.

---

An older type appliance plug used for connecting some type of appliances like clothes irons and kettles.
Insulation Resistance
All equipment must be tested to ensure the integrity of the insulation to isolate any live parts. A insulation resistance tester is the instrument used here. This instrument is designed to measure very high values of resistance, over 1 MΩ (1 million ohms) from any live conductor and its protective earth or exposed metal part.

Polarity Active Pins
The resistance must not be greater than 1Ω. The test is called a continuity test and ensures the ‘active to active’ polarity is correct.

Polarity Neutral Pins
The resistance must not be greater than 1Ω. The test is called a continuity test and ensures the ‘neutral to neutral’ polarity is correct.
Cords, Cables & Plugs

Purpose:
In this section you will develop knowledge and skills required to select, assemble and connect cords and plugs for voltages up to 250V.

To Achieve the Purpose of this Section:

At the end of this practical assignment the student will be able to:

- Select appropriate flexible cords for given applications
- Prepare cord ends for connection
- Fit a standard 3 pin plug top to a flexible cord
- Fit a standard three pin extension socket to a flexible cord
- Connect a variety of plugs to different flexible cord types
- Use basic test equipment to test and locate various faults in flexible cords and cables

Equipment:
The equipment needed for this practical exercise are listed in each section.

References:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 320-323, Pearson Education Australia. French’s Forest NSW 2086
NOTE:
This practical is to be completed by students on an individual basis

PREPARING THE CORD END

Using the instruction diagram on the plug or socket packaging as a guide:

PRACTICAL EXERCISE 1
MAKE AN EXTENSION LEAD

Material:
- 1 metre, three core T.P.S. flex cable
- 1 Three pin plug top (clear)
- Three pin socket (clear)

Tools:
- Boot knife
- Combination pliers

Step 1: Cut a length of flexible cable 1.0 metre long
Step 2: Examine the ends of the flexible cable to determine the cable sequence that will suit each end of the lead.

Step 3: Strip the sheathing approximately 100 mm.

*Take care not to damage the insulation around the inner cores.*

The cable cores can be temporarily installed in the plug top and the socket to gauge their correct length.

**Step 4:** Strip the cable core Approximately 20 mm. **Do not damage the conductor.** Twist the exposed conductor to give a compact group then double over to give a larger area for termination.

If the plug or socket will not accept a doubled over conductor, trim them to 10 mm in length and insert without doubling over.
**Step 5:** Slide the cord-grip nut and the plug cover onto the three-core cable. Using the end which suits the **plug sequence** (i.e. there is no cross over of conductor cores) and terminate the plug end.

*Note:* The plug shroud should not be pushed on until the terminations, cable condition and cable wrap around the cable anchoring points have been checked by the teacher.

![Plug connections, rear view](image)

**Step 6:** Slide the cord-grip nut and the socket cover onto the three-core cable. Using the end which suits the **socket sequence** (i.e. there is no cross over of conductor cores) terminate the socket end.

*Note:* The socket shroud should not be pushed on until the terminations, cable condition and cable wrap around the cable anchoring points have been checked by the teacher.

![Socket connections, rear view](image)
STUDENT NAME ________________________

Use the appropriate test equipment and check the following:

<table>
<thead>
<tr>
<th>Test</th>
<th>Check</th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuity between active pins on plug and socket</td>
<td></td>
<td>/1</td>
</tr>
<tr>
<td>2. Continuity between neutral pins on plug and socket</td>
<td></td>
<td>/1</td>
</tr>
<tr>
<td>3. Continuity between earth pins on plug and socket</td>
<td></td>
<td>/1</td>
</tr>
<tr>
<td>4. Insulation resistance Active to Earth</td>
<td></td>
<td>/1</td>
</tr>
<tr>
<td>5. Insulation resistance Neutral to Earth</td>
<td></td>
<td>/1</td>
</tr>
<tr>
<td>6. Insulation resistance Active to Neutral</td>
<td></td>
<td>/1</td>
</tr>
</tbody>
</table>

**Teacher check**

<table>
<thead>
<tr>
<th>Test</th>
<th></th>
<th>Mark</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Correct pin polarity for plug</td>
<td></td>
<td>/4</td>
</tr>
<tr>
<td>8. Correct pin polarity for socket</td>
<td></td>
<td>/4</td>
</tr>
<tr>
<td>9. No cuts or nicks on insulation or conductors</td>
<td></td>
<td>/4</td>
</tr>
<tr>
<td>10. Plug and socket covers correctly fitted</td>
<td></td>
<td>/2</td>
</tr>
</tbody>
</table>

**TOTAL**                                                |       | /20  |
PRACTICAL EXERCISE 2 - FIND FAULTS IN APPLIANCE LEADS

Using the appliance leads supplied:

- Test and inspect each lead and record the results in the tables below

### Tests to Perform on Lead 1

<table>
<thead>
<tr>
<th>Test to Perform on Lead 1</th>
<th>Meter Scale</th>
<th>Reading</th>
<th>Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuity between active pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Continuity between neutral pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Continuity between earth pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Insulation resistance Active to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Insulation resistance Neutral to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Insulation resistance Active to Neutral</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual inspection (OK or faulty)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the Lead OK or faulty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Test to Perform on Lead 2

<table>
<thead>
<tr>
<th>Test to Perform on Lead 2</th>
<th>Meter Scale</th>
<th>Reading</th>
<th>Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuity between active pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Continuity between neutral pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Continuity between earth pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Insulation resistance Active to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Insulation resistance Neutral to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Insulation resistance Active to Neutral</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual inspection (OK or faulty)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the Lead OK or faulty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Test to Perform on Lead 3

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Meter Scale</th>
<th>Reading</th>
<th>Fault</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continuity between active pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Continuity between neutral pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Continuity between earth pins on plug and socket</td>
<td>Ω</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Insulation resistance Active to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Insulation resistance Neutral to Earth</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Insulation resistance Active to Neutral</td>
<td>MΩ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual inspection (OK or faulty)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the Lead OK or faulty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Cords, Cables & Plugs**

*These questions will help you revise what you have learnt in Section 2. Write down the AS/NZS 3000:2007 reference with each answer when it is used.*

1. The international colour code for three core flexible cords for use with single-phase appliances is:
   (a) Blue active; Black neutral; Green/yellow earth
   (b) Brown active, Black neutral; Green earth
   (c) Red active; Black neutral; Green earth
   (d) Brown active; Blue neutral; Green/yellow earth

2. The international protection rating (IP) of a plug or socket indicates the level of protection against:
   (a) Fault currents
   (b) Over voltage
   (c) The ingress of moisture and foreign bodies
   (d) Earth faults

3. A 230V double insulated portable electric drill must:
   (a) Have a minimum earth resistance of 1 ohm
   (b) Have a resistance between active and neutral terminals greater than 1 M ohms
   (c) Not be earthed
   (d) have an insulation resistance not exceeding 1M ohms

4. The continuity of a flexible cord is best tested using:
   (a) An ohmmeter
   (b) Test lamps
   (c) A voltmeter
   (d) A test pencil
5. Before working on a cord-connected appliance it is important to first:
   (a) Remove the appliance terminal cover
   (b) Test the appliance with an insulation tester
   (c) Test the supply at the appliance terminals
   (d) Isolate the appliance by removing the plug from the socket

6. The resistance between the active and neutral pin of the plug top used to connect an appliance, should be:
   (a) Less than 2 ohms
   (b) Greater than 2 ohms
   (c) Greater than 1 M ohms
   (d) Determined by the wattage rating of the appliance

7. “Figure eight” type flexible cords may be used for:
   (a) Double insulated appliances
   (b) Hand held appliances only
   (c) Double and single insulated appliances
   (d) Appliances fitted with robust metal jackets, to provide mechanical protection

8. The CSA of the conductors in a flexible cord used to supply an appliance is determined by the:
   (a) Mechanical stresses that the cord will be subjected to
   (b) Load current required by the machine
   (c) Amount of flexing that the cord will be subjected to
   (d) Insulating ability of the cable covering material

9. Why is the earth pin of a three-pin plug longer than the other two?
   ____________________________________________________________

10. Why is the earth pin of a three-pin plug sometimes wider than the other two?
    ____________________________________________________________

11. Answer review questions 1-4 on page 323 of your textbook.
FLAT TPS Wiring Systems

PURPOSE:
In this section you will develop your skills in using thermoplastic sheathed (TPS) cable with skirting trunking and lighting looms.

TO ACHIEVE THE PURPOSE OF THIS SECTION:
At the end of this section the student will be able to:

• Determine the Australian Standards requirements for the installation and protection of flat TPS cable
• Install flat TPS cable in trunking and duct for the supply of socket outlets.
• Use flat TPS cable to assemble and install a lighting loom.
• Test circuits to ensure they are safe and operate as intended.

REFERENCES:

• AS/NZS 3000:2007
• AS/NZS 3008: 2009
• Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 324 -364, Pearson Education Australia. French’s Forest NSW 2086
1. INTRODUCTION

Thermoplastic sheathed and insulated cables (_____) form the most commonly used wiring system in commercial and domestic installations. Many installation methods rely on the double insulation provided by the insulation and sheath to maintain the minimum standard for safety required by AS/NZS 3000:2007.

The main reasons for use of TPS wiring systems include:

- It is quickly and easily ____________________ for surface work
- It is even more ____________________ for concealed systems
- If used with all ____________________ accessories it forms a complete double insulated system. (1.4.60c)
- Available with or without an _________________ conductor (earth conductor will simplify some installations)

The disadvantages to using TPS wiring include:

- It is prone to ____________________ damage during installation and in use.
- It can be damaged by rodents.
- The presence of excessive _____________ can damage or degrade it.
- The PVC sheath is chemically inert in most environments, but there is a likelihood of solvents affecting cable insulation (*Organic solvents (acetone and ketone) and oxidising acids (nitric and sulphuric acids)*)

Applications

- Commercial and domestic ______________ and _______________ circuits
- Underground wiring, if suitably _________________ – Clause 3.11 & Table 3.6
- Certain external situations (preferably UV protected)

In this section, you will learn about installation techniques often used with flat, multicore TPS cables in non-domestic installations.

- TPS cables are categorised as either _______________ or _______________.
2. TPS CABLES USED IN TRUNKING SYSTEMS

What is trunking?
Read the definitions in AS/NZS 3000:2007 Clause ___________ (trunking) and Clause ___________ (duct) to answer the question.

Restrictions for use
AS/NZS 3000, Clause ___________ outlines requirements for trunking systems. General requirements on use of wiring enclosures are in AS/NZS 3000 Clause ___________ – Enclosure of cables

The maximum number of cables in a trunking system is only limited by the space available for the cables. Furthermore, it should permit installation of the cables without ___________. The cable rating ___________ if more than one circuit is in the trunking.

A range of accessories is available to make the installation of trunking systems quick and easy. All metal systems used as skirting trunking have a range of kits that will help you install accessories such as socket outlets, data outlets and telephone points directly on sections of the cover of the trunking.
Segregation

The Australian Communications Authority (ACA) Regulations and AS/NZS 3000 Clauses 3.9.8.3 and 3.9.8.4 require low voltage cables to be segregated from cables of other systems, particularly ____________________________ services.

Skirting trunking provides the required segregation by using separate channels formed within the trunking.

Where it is possible to remove the cover of cable trunking without the use of tools, you should install ________ cables in the trunking. Refer to AS/NZS 3000 Clause 3.10.2.1c.
3. INSTALLATION

Trunking is installed, cables are laid and the lid is then fitted to the trunk.

- Has a removable lid, giving ready access.
- May be mounted on the surface or may be concealed.
- Easy access for repairs or additions
- Metal or P.V.C.
- Floor or skirting trunk.
- Used in large switchboards and control cabinets
- Accessories are made from the same material as the trunk.
- A fault in cable can affect adjoining cables.

Cable duct is a ________ passage for cables, so they must be drawn in after the installation of the duct. (i.e. no access apart from either end or at joins) If the duct is in the form of a pipe, it will be classified as a duct only if it has a diameter 75 mm or greater (otherwise it is known as ___________).

- The terms trunking, ducting, cable raceway and troughing are often interchanged.
- Mutual heating of bunched cables will lead to cable current ‘__________’.
4. WIRING USING A LIGHTING LOOM

Prefabricating a wiring loom or harness in a workshop or on site is an efficient method of installing wiring where there are several very similar floor layouts. This technique is suited to multi-storey construction where the lighting layout is virtually identical on all floors.

The cables are in a position ________________________________________________________________________, (suspended ceilings – 3.9.3.2) so you do not need any further enclosure or protection.

Loom wiring is a system in which ___________ cables are installed in the space between the underside of a concrete slab or roof structure and a false ceiling, for the supply of plug in lighting units.

- Loom or Harness consists of cable and socket outlets.
- Loom is prepared in a convenient location, such as on the floor or in a factory, and then fixed into position.
- Four and five wire looms are used where emergency lighting, dimming of fluorescent lights or selective switching, such as switching office lights off after hours, is required.

Most manufacturers of wiring and electrical accessories have a range of products suitable for this type of wiring method. For example lighting 'plugs' into sockets having three or four pins. You fix these sockets to base plates fixed to the underside of the upper floor.
5. INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007.

Refer to the following requirements and AS/NZS 3000:2007 clauses:

- Clause 3.9.7.2(b)(i)
- Clause 3.9.7.2(b)(ii)
- Clause 3.3.2.6
- Clause 3.9.4
- Clause 3.9.4.2
- Clause 3.9.4.3
- Clause 3.9.4.4
- Clause 3.9.3.3
- Clause 3.9.6
- Clause 3.9.3
- Clause 3.3.2.8
- Clause 3.9.9.3
- Clause 3.9.8.3 and ACA rules
- Clause 3.9.8.4 and ACA rules
- Clause 3.13
6. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- Continuity of the earthing system is safe and sufficiently low  
  Clause 8.3.5
- Insulation resistance is safe and sufficiently high  
  Clause 8.3.6
- Polarity is correct - including switches controlling active conductors Clause 8.3.7
- There is no transposition of earth and neutral conductors  
  Clause 8.3.7
- There are no short circuits between conductors  
  Clause 8.3.8
- There are no interconnections with another circuit  
  Clause 8.3.8
- Verification of earth loop impedance Clause 8.3.9
- Operation of RCDs  
  Clause 8.3.10
- Circuit control and protection devices on the main switchboard are correctly marked to indicate:  
  Clause 2.9.5
  - corresponding active and neutral conductors for each circuit
  - relationship of equipment and the various parts of the installation

7. INSULATION RESISTANCE (MEGGER TEST) (CLAUSE 8.3.6)

_______ DC is used to ‘stress’ the insulation to ensure resistance between all live conductors & EARTH exceeds _______ (1 million ohms) or _________ (10,000 ohms) for appliances with heating elements.

- (Where the working voltage is no more than 250V AC the test voltage is 500V DC. If the working voltage is higher the test voltage is specified as 1000V DC.)
- Test is performed at the Main Switch Board (Power OFF)
- A – E > _____________
- N – E > _____________
- Don’t “Megger” between A & N in cases where electronic circuitry (dimmers, fan controllers) is used. Potential will damage components.
- On large industrial units the earth and active are sometimes joined. That is: Connect a short circuit between the circuit conductors and the earth conductor
TPS WIRING SYSTEMS 1

PURPOSE

In this topic you will develop your skills in using thermoplastic sheathed (TPS) cable with skirting trunking and lighting looms

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this practical assignment the student will be able to:

- determine AS/NZS 3000 requirements for the installation of flat TPS cable
- list the materials needed in the job specification
- install flat TPS cable in skirting trunking and floor duct for the supply of socket outlet
- use flat TPS cable to assemble and install a lighting loom
- test circuits to ensure they are safe and operate as intended

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

- AS/NZS 3000:2007
- AS/NZS 3008.2009
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 324 -364, Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students on an individual basis.
1. JOB SPECIFICATION

a) The installation consists of two socket outlets install in metal floor skirting duct
b) The installation of two lighting points in skirting trunking

The fixed wiring is to originate from the switchboard.

Lighting circuit cable size ________________ Power circuit cable size ____________

The circuit protection must be an appropriate circuit breaker for the circuits

Size of circuit breaker for the light circuit using _____ sq mm tps cable ___________
Size of circuit breaker for the power circuit using _____ sq mm tps cable___________

All work to be carried out to comply with AS/NZS 3000 installation rules
2. **ADD LIGHTING LOOM TO WIRING JOB** (OR REPLACE LIGHTS LP1&LP2 WITH LIGHTING LOOM)

3 Pin Plug bases for the connection of light fittings.

![Diagram](image)

1 or 1.5mm² Twin & Earth

Connect loom to LP 2

3. **MATERIAL LIST**

1. List the materials needed to install the lighting final subcircuit and enter in table 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2. List the materials needed to install the power final subcircuit and enter in table 2

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. **LIGHTING CIRCUIT**

1. Complete the wiring diagram for the two lights controlled by individual switches, use the loop at the light method.
5. POWER CIRCUIT

1. Complete the wiring diagram for the two socket outlets wired in 2.5mm² T&E.

![Wiring Diagram]

6. SWITCHBOARD

1. Complete the wiring diagram for the switchboard.

![Switchboard Diagram]
7. BOARD LAYOUT

![Board Layout Diagram]
<table>
<thead>
<tr>
<th>Circuit testing and inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth Continuity Test</td>
</tr>
<tr>
<td>Meter Used</td>
</tr>
<tr>
<td>Insulation Resistance Test (light circuit)</td>
</tr>
<tr>
<td>Meter Used</td>
</tr>
<tr>
<td>Insulation Resistance Test (Power circuit)</td>
</tr>
<tr>
<td>Meter Used</td>
</tr>
<tr>
<td>Polarity Test (Socket Outlets) Using test resistors</td>
</tr>
<tr>
<td>Active – Earth (Ω)</td>
</tr>
<tr>
<td>Circuit Operates correctly</td>
</tr>
<tr>
<td>Lights</td>
</tr>
</tbody>
</table>

Student’s Name:
Signature:
Mark /
These questions will help you revise what you have learnt in Section]. Look up the AS/NZS 3000:2007 reference to find each answer when it is used.

1. Determine the minimum size of cable required for the two socket outlets, wired in TPS cable and enclosed in skirting duct

__________________________________________

AS/NZS3000 T3.3

2. Determine the minimum conductor size required for the lighting circuit, wired in TPS cable and enclosed in PVC duct

__________________________________________

AS/NZS3000 T3.3

3. What segregation is required when installing telephone and low voltage cables in skirting duct?

__________________________________________________________________

__________________________________________________________________

____________________________________________

AS/NZS3000 3.9.8.4.c

4. What is the definition of cable trunking

__________________________________________________________________

__________________________________________________________________

____________________________________________

AS/NZS3000 1.4.97

5. What is the polarisation (polarity) of a single phase three pin socket outlet?

__________________________________________________________________

__________________________________________________________________

____________________________________________

AS/NZS3000 4.4.5

6. What is the definition for Cable duct

__________________________________________________________________

__________________________________________________________________

____________________________________________

AS/NZS3000 1.4.42
7. Is it permissible to use single insulated cable in PVC trunking?

__________________________________________  AS/NZS3000  3.10.2.1

8. In an area that is likely to be disturbed, what is necessary for the removal of the covers of cable trunking?

__________________________________________  AS/NZS3000  3.10.2.1

9. Describe the maximum spacing for supports for cables installed in positions considered as 'likely to be disturbed'.

__________________________________________  AS/NZS3000  3.9.3.3

10. When can the earthing conductor be less than 2.5mm²?

__________________________________________  AS/NZS3000  T5.1

11. Answer review questions 1, 2 & 24 from page 343 and questions 1 - 8 on page 364 in your textbook.

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
CIRCULAR TPS WIRING SYSTEMS

PURPOSE:

In this section you will develop your skills in using circular TPS cable with cable tray, sealing glands and IP56 accessories

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

a. Determine Australian Standards requirements for the installation of circular TPS cable.

b. Install a final sub-circuit for lighting using circular TPS cable on a cable tray.

c. Install a 5 pin socket outlet using circular TPS cable maintaining an IP56 rating.

d. Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
- AS/NZS 3008.2009
- Hampson, Jeffery, *Electrotechnology Practice*, Section 10 pgs 324 -364, Pearson Education Australia. French’s Forest NSW 2086
1. CIRCULAR TPS CABLE ON A CABLE TRAY AND LADDER

The thermoplastic wiring systems used in this section are more common in industrial applications. You will learn about typical installation methods that are suited to the installation of circular TPS cables. The round shape of the cable generally makes it easier to seal the cable entry into accessories, against moisture.

__________ and ____________ systems are often used with TPS cables, flat and circular in ____________ and ____________ installations. Both can be made from galvanised steel or aluminium (although steel is structurally stronger) which are easily fabricated on site.

When installed outdoors the cable is normally ____________ for U.V. protection. Cable tray is perforated (not less than 30%). Perforations allow air circulation and the attachment of cables using cable ties.

The following table compares the two systems:

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ladder</strong></td>
<td></td>
</tr>
<tr>
<td>• Heavy duty construction, much stronger than tray</td>
<td>• More expensive than tray</td>
</tr>
<tr>
<td>• Larger distances between supports compared with tray</td>
<td>• Not as adaptable as tray and not as easy to install</td>
</tr>
<tr>
<td>• Very high level of air circulation permitted around cable.</td>
<td>• Smaller range of sizes</td>
</tr>
<tr>
<td>• More suited to larger cable sizes (metal work takes up 10% or less of the space)</td>
<td></td>
</tr>
<tr>
<td><strong>Tray</strong></td>
<td></td>
</tr>
<tr>
<td>• Less expensive than ladder</td>
<td>• Needs more support and fixings than ladder</td>
</tr>
<tr>
<td>• Wide range of sizes available</td>
<td>• Less air circulation around cables than ladder</td>
</tr>
<tr>
<td>• Highly adaptable, easy to fit to building profile</td>
<td></td>
</tr>
</tbody>
</table>
2. CABLE DERATING

If not enough space is allowed between cables of other circuits, the amount of cooling air will be restricted possibly causing the cables to ______________. It is necessary to ______________ the maximum current the cable can carry to limit the heat produced in the cable. In other words, the current-carrying capacity of the cable is reduced. This is called ______________.

Figure 1, page 26, in AS/NZS 3008.1.1:2009 shows the minimum clearance between cables so they do not require derating. This table is shown below.

<table>
<thead>
<tr>
<th>Single-core cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of installation</td>
</tr>
<tr>
<td>Cables suspended from a catenary wire where air circulation is unrestricted or spaced from surfaces and supported on ladders, racks, hangers or cleats where the impedance of the air flow around the cable is not greater than 10%</td>
</tr>
<tr>
<td>Cables spaced from surfaces and supported on perforated or unperforated cable trays where air circulation is partially restricted</td>
</tr>
<tr>
<td>Cables fixed directly to a wall, floor, ceiling or similar surface where air circulation is restricted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Multicore Cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method of installation</td>
</tr>
<tr>
<td>Cables suspended from a catenary wire where air circulation is unrestricted or spaced from surfaces and supported on ladders, racks, hangers or cleats where the impedance of the air flow around the cable is not greater than 10%</td>
</tr>
</tbody>
</table>
Cables spaced from surfaces and supported on perforated or unperforated cable trays where air circulation is partially restricted

Cables fixed directly to a wall, floor, ceiling or similar surface where air circulation is restricted

Minimum cable spacings in air to avoid derating

The following factors affect the actual current carrying capacity of the cables:
- Cross sectional area of conductor
- Type of insulation
- Arrangement of cables – bunching/bundles
- Installation methods
- Type of cable (single or multicore)
- Clearances between cables and other tiers of cable support systems

For more information about cable selection, based on current carrying capacity, you should refer to sections 2.3, 3.4, 3.5, and Tables 3 to 29 of AS/NZS 3008.1.1

3. CABLE SUPPORT

One of the quickest methods for supporting the cables on the tray is to _________ the cable at suitable intervals. Several manufacturers make nylon ties for this purpose. The distance between the ties will depend on the arrangement of the tray and proper work practice.

4. CIRCULAR TPS CABLE AND WEATHERPROOF FITTINGS

The round shape of the circular TPS cable makes it easy to seal the cable entry into accessories and appliances against moisture. There are several types of cable gland that can be used to maintain the IP rating of weatherproof accessories.
Two common types of compression glands are:

- Nylon; black or grey in colour
- Metal; usually chrome plated brass

The cable gland grips the sheath of the cable. A compression ring made of a long lasting synthetic, rubber-like material called neoprene helps to seal the gland against the weather.

5. IP (INTERNATIONAL PROTECTION) RATING OF ACCESSORIES

The degree of protection provided by enclosures of electrical equipment can be determined by the tests of AS 60529. The standard considers the protection of persons against access to hazardous parts __________ of the enclosure, against __________ of solid foreign objects and the ______________ of the equipment inside the enclosure against harmful effects due to the ingress of water.

*See figure 2.27 in your textbook on page 72*
6. INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. Refer to the following requirements and AS/NZS 3000 clauses:

- Clause 3.9.3
- Clause 3.3.2.8
- Clauses 1.4.40
- Clause 6.1.2
- Clause 6.3.2.1
- Clause 6.7
- Appendix G

- You should check that the supports for the tray are suitable and check to see if an earth or bond is necessary for the metal cable tray

7. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- Earth resistance is safe and sufficiently low Clause 8.3.5
- Insulation resistance is safe and sufficiently high Clause 8.3.6
- Polarity is correct - including switches controlling active conductors Clause 8.3.7
- There is no transposition of earth and neutral conductors Clause 8.3.7
- There are no short circuits between conductors Clause 8.3.8
- There are no interconnections with another circuit Clause 8.3.8
- Verification of earth loop impedance Clause 8.3.9
- Operation of RCDs Clause 8.3.10
- Circuit control and protection devices on the main switchboard are correctly marked to indicate:

  The corresponding active and neutral conductors for each circuit and the relationship of equipment and the various parts of the installation. Clause 2.9.5
CIRCULAR TPS Wiring Systems

PURPOSE:
In this topic you will develop your skills in using circular thermoplastic sheathed (TPS) cable.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this practical assignment the student will be able to:
- determine AS/NZS 3000 requirements for the installation of circular TPS cable
- list the materials needed in the job specification
- install circular TPS cable on cable tray for the supply of a single phase socket outlet
- use circular TPS cable to assemble and install a lighting point
- test circuits to ensure they are safe and operate as intended.

EQUIPMENT:
The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:
- AS/NZS 3000:2007
- AS/NZS 3008.1.1:2009
- Hampson, Jeffery, Electrotechnology Practice, Section 3 pgs 324 - 364, Pearson Education Australia. French’s Forest NSW 2086

NOTE:
This practical segment is to be completed by students on an individual basis.
1. **JOB SPECIFICATION**

1. The installation consists of a single phase 10 amp socket outlet using circular TPS cable
2. The installation of a lighting point using circular TPS cable

The fixed wiring is to originate from the switchboard.

Lighting circuit cable size ________________ Power Circuit cable size ____________

The circuit protection must be an appropriate circuit breaker for the circuits

Size of circuit breaker for the light circuit using _____ sq mm TPS cable ____________

Size of circuit breaker for the power circuit using _____ sq mm TPS cable ____________

**All work to be carried out to comply with AS/NZS 3000 Installation Rules**
2. MATERIAL LIST

1. List the materials needed to install the lighting and power final sub-circuit and enter in table 1

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</table>
3. LIGHTING CIRCUIT

1. Complete the wiring diagram for the lighting point controlled by an individual switch.

4. POWER CIRCUIT

Complete the wiring diagram for the single phase outlet.
5. SWITCHBOARD WIRING

1. Complete the wiring diagram for the switchboard with RCD protection.
6. BOARD LAYOUT
CIRCULAR TPS WIRING SYSTEMS

These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.

Q1 Where circuits are wired in TPS cable and fixed to metal cable tray, must the cable tray be earthed?

________________________________________________________________________

AS/NZS3000

Q2 Which conductor is wired into the circuit breaker?

________________________________________________________________________

AS/NZS3000

Q3 What is the minimum insulation resistance acceptable for live parts of cables to earth?

________________________________________________________________________

AS/NZS3000

Q4 Is the orange circular TPS cable used in the exercises regarded as armoured cable?

________________________________________________________________________

Q5 To measure the insulation resistance of the circuits, what DC voltage setting on the megger should be used?

________________________________________________________________________

AS/NZS3000

Q7 What colours or combination of colours must be used to identify an earthing conductor?

________________________________________________________________________

AS/NZS3000
Q8  Can black cable be used for the switch wire of a fixed lighting circuit

AS/NZS3000

Q9  How much insulation should be removed when terminating a cable?

AS/NZS3000

Q10  Electrical connections between conductors and equipment shall provide

continuity, appropriate _____________ and _____________ strength.

AS/NZS3000

Q11  Answer questions 9 -14 on page 364 of your textbook
TPI IN NON-METALLIC ENCLOSURES

PURPOSE:

In this section you will develop your skills in using thermoplastic insulated cables in non-metallic conduit & trunking

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of non-metallic enclosures
- Cut and set rigid non-metallic trunking and conduit and accessories
- Install circuits using TPI cables in non-metallic enclosures
- Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 3 pgs 324 -364, Pearson Education Australia. French’s Forest NSW 2086
1. TYPES OF WIRING ENCLOSURES – 3.10.2.1 (See page 324 in your textbook)

- The protection offered by the sheath of the cable will be inadequate for some conditions.
- Cables will sometimes need the added _____________ of conduit or other types of _____________.
- It is usual to use single insulated unsheathed (_____ ) cables in these situations to save space in the enclosure and reduce costs.

AS/NZS 3000:2007 has some requirements you must follow when installing electrical equipment. These specifications generally refer to the following _______________ wiring enclosures:

- Rigid PVC conduit (UPVC – unplasticised polyvinyl chloride)
- HFT conduit (Halogen free, fire resistant, temperature stable)
- Flexible non-metallic (PVC) conduit
- Corrugated PVC conduit
- Non-metallic trunking

2. RIGID PVC CONDUIT

A complete conduit installation is considered to be _______________________, that is, there can’t be any short circuits to earth.

Manufacturers of PVC conduit produce a standard range of pipes and tubes from 16 mm outside diameter to 63 mm outside diameter for the medium duty (MD) range. Medium duty conduit is _________________ in colour.

HFT conduit is ________________ while for telecommunication installations ________________ conduit is used.

The heavy-duty range starts at 16 mm outside diameter to 150 mm outside diameter. Heavy duty conduit is _________________ in colour.

Note: Clause 1.4.42 of AS/NZS 3000:2007 defines conduit having a diameter of 75 mm or more as a _______________.

Rigid PVC conduit may also have a cross section that is oval. Oval conduit is generally buried beneath plaster or render.

3. TYPICAL APPLICATIONS

Generally medium duty conduit is used _______________ in places where there is little chance the conduit will be damaged, while the main use for heavy-duty conduit is for the enclosure of cable ________________.

4. PROHIBITED USE

The usefulness of PVC conduit reduces in hot or very cold places. Certain chemical solvents will also reduce the protection offered by the conduit.

- PVC conduit _______________ when hot, becomes _______________ when cold.
- It is prohibited or limited in use by other standards and codes for ____________, ____________, and ____________ areas.
- PVC conduit is “notch sensitive” – scratches and nicks on the surface can become a point of failure during bending operations.
5. INSTALLATION  (See page 332-323 in your textbook)

You need to make allowances for the physical properties of PVC conduit when you shape and fix it in position. In particular you must consider support and the high rate of expansion of the conduit.

- Cut the conduit to length using a hacksaw or conduit cutters. All sharp edges must be _________________ to avoid cable insulation damage.

- Support (saddle) spacing should not exceed approximately ________________.

- Rigid conduit has an expansion rate of 1 mm per metre for each 10° increase in temperature. Expansion joints are recommended every 4 metres where temperature variations occur. Saddles should allow for movement due to expansion.  See Figure 10.76 & 10.77 on page 333 in your textbook.

- Some types of conduit are not suitable for use in direct sunlight without further protection. Ultra violet light leads to a degradation of the conduits’ impact strength of up to 10%. If conduit is subject to direct sunlight a conduit made to AS/NZS 2053.1 and marked with a “____” must be used, or the exposed conduit painted with a light coloured ___________________________ paint.

- Joins should be made using an adhesive supplied or recommended by the manufacturer.

- Sets and bends must be made so as not to ____________ the passage for the ___________. (3.10.3.4.) Bends are made with an internal spring. (See Figure 10.73 page 332 in your textbook). The minimum bend radius for the cable is _______ times the cable diameter. (3.9.6)
Section 5

- All conduits should be installed **before** the cables are drawn in. Junction boxes, inspection Tees and elbows are used to allow the draw to happen in short runs. Lubricant is available to ease the operation.

- Connection to accessories should be done using the correct conduit adaptors. ____________________________ adaptors are available to join to threaded parts.

- When installing multiple circuits in the same enclosure, be aware that mutual heating may become a factor. Use the tables in AS/NZS 3008.1.1 to determine the current carrying capacity of cables bunched or grouped in enclosures. Appendix C and tables C9, 10 and 11 of AS/NZS3000:2007 provide guidance to the number of cables permitted in conduit.

- HFT conduit ________________ be bent therefore bends, elbows and tees should be used to change direction.

1. CORRUGATED PVC CONDUIT

*See samples provided or Figure 10.91 page 339 in your textbook.*

**Applications**

You can use corrugated conduit as a replacement for rigid PVC conduit. Corrugated conduit can be medium duty (grey) or heavy duty (orange). Electricians like the convenience of corrugated conduit, especially when there is a need to bend the conduit around sections of a building or in a concrete deck. Corrugated conduit is _____ a replacement for flexible conduit and is _____ suitable if continuous flexing is required.

**Joints and terminations**

You can glue joints and terminations to standard fittings using a suitable adhesive or use specially designed fittings to terminate the conduit.

**Support**

The same rules that cover the support of flexible conduit apply to corrugated conduit. Generally, you must have enough supports to prevent excessive ______ and ______.
2. Flexible non-metallic (PVC) conduit

(See samples or Figure 10.92 on page 339 in your textbook).

Flexible PVC conduit is manufactured in a range of sizes from 16 mm inside diameter to 63 mm inside diameter. Flexible conduit is measured across the _________ diameter and rigid PVC conduit is measured across the _________ diameter.

Restricted use

Generally, you may use flexible non-metallic conduit in similar situations to rigid PVC conduit or where continuous flexibility is required. It is best used where a connection is to be made between a _______ point and an _____________, such as a stove, or a machine that is subject to ___________ or ______________.

Anchorage and support

It is necessary to suitably support any wiring enclosure to prevent damage to the enclosure and any associated cables.

Saddles used to support flexible conduit will need to be one size larger than the nominal size of the conduit. For example, 20mm flexible conduit has a bore of about 20mm and an outside diameter of about 25mm; therefore 25mm saddles are used to support this conduit.

Fittings (See pictures and samples provided by your teacher)

The fittings for flexible conduit must not collapse or distort the tube.

The fittings for terminating flexible conduit are called ______________.

Terminators can be straight or angled. Angled terminators have either a sweeping 90° bend (called angled) or a right angle that has a smaller radius bend (called right angle). These types of terminators are suitable where you need to terminate the conduit in an appliance where space is limited. For example: at the back of a stove or water heater that will be pushed back against the wall.

Terminators generally cause a reduction in the core diameter at the end of the conduit that may make it difficult for you to draw in cables. Consider using the next larger size conduit if the number of cables is close to capacity.
3. TRUNKING (See samples, pictures and Figure 10.60 on page 324 in your textbook).

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Section 5  TPI in Non Metallic enclosures - Miller College

Trunking comes in ______________ or ______________ sections with removable covers. Trunking also comes in a variety of materials, however in this section we will only cover the regulations that apply to non-metallic systems.

PVC trunking is available in sizes from 10 mm x 6 mm to 100 mm x 100 mm.

Covers (3.10.2.1c)

Cable trunking containing ______________ cables must have covers. If the trunking is in a readily accessible position, then the covers must need __________ to remove them. The cover can not be used as support for the cable nor can the cable be attached to the cover.

Limitations on use

You must have access to a cable trunking system throughout its entire length. Use of the trunking system is restricted in damp situations or where it may suffer mechanical damage.

Installation of cables

Generally, the same rules apply to trunking that apply to other wiring systems. You can fit as many cables into the enclosure as you can without __________ the cables during installation.

The practical limit is determined by:

- __________ requirements for the current carrying capacity of the cables.
- The cables having to stay in place when the lid is __________.

Cables of some systems should not be enclosed with low voltage systems. For example; Telecommunication cables must be __________ from low voltage systems.

Cables in a trunking system should be arranged to allow for the circulation of _______ to help remove any ________.
Passage through walls and floors

When the trunking system passes through a fixed barrier like a wall or floor, it must be a complete section. Any gaps around the trunking or around the cables in the trunking must be filled with a suitable barrier to inhibit the spread of __________.

Extra care needs to be used when enclosures must pass through fire barriers. In general the size of the opening is limited and the fire rating of the barrier must be ______________ after installation. More information is found in clause 3.9.9.3 of AS/NZS 3000.
## PVC and steel conduit compared

<table>
<thead>
<tr>
<th>PVC Rigid Conduit</th>
<th>Steel conduit</th>
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<tbody>
<tr>
<td>Simple to set to required shapes and angles</td>
<td>Difficult to set to involved shapes or curves, other than those allowed by the bending tools.</td>
</tr>
<tr>
<td>Set may be fairly tight while still being smooth</td>
<td>Fairly large radius need in all sets, to avoid collapsing the conduit.</td>
</tr>
<tr>
<td>Cut edges are simple to smooth off, and do not damage the cabling.</td>
<td>Cut edges need to be filed or rounded. Some require the fitting of bushes.</td>
</tr>
<tr>
<td>Considerably less expensive than steel conduits.</td>
<td>Much more expensive than PVC rigid conduit.</td>
</tr>
<tr>
<td>Joints are simple push fit, with glue.</td>
<td>Joints must be made by way of threaded conduit ends and fittings.</td>
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<tr>
<td>Fixings must be no more than 1 metre apart.</td>
<td>Fixings may be up to 2 metres apart.</td>
</tr>
<tr>
<td>PVC conduit is susceptible to mechanical damage.</td>
<td>Steel conduit is very suited to protecting cabling where there is a risk of mechanical damage.</td>
</tr>
<tr>
<td>PVC should not be used where the temperature exceeds 60°C.</td>
<td>Steel conduit does not deteriorate at high installation temperatures.</td>
</tr>
<tr>
<td>PVC conduit does not protect cabling against fire.</td>
<td>Steel conduit will protect cabling from the effects of fire for a limited time, so fire protection equipment can continue to operate for that period.</td>
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<tr>
<td>Under fire conditions, PVC conduit will burn, giving off noxious gases and solids.</td>
<td>Steel conduit will not burn, and will contain any noxious gases produced by the cables it contains.</td>
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<tr>
<td>PVC conduit is virtually unaffected by moisture, acids or alkalis.</td>
<td>Steel conduit must be protected against the corrosive effects of moisture, acids or alkalis.</td>
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<tr>
<td>Solvents and similar materials greatly affect the composition and structural stability of PVC conduits.</td>
<td>Steel conduit is unaffected by most solvents.</td>
</tr>
<tr>
<td>PVC conduit is prohibited where explosive gases may be present.</td>
<td>Steel screwed conduit is an acceptable cabling enclosure where explosive gases may be present.</td>
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<tr>
<td>PVC conduit is susceptible to damage by ultra-violet light.</td>
<td>Steel conduit is unaffected by ultra-violet light.</td>
</tr>
<tr>
<td>HD PVC conduit may be used as a Category A underground wiring enclosure, and other PVC conduits as a Category B enclosure.</td>
<td>Steel conduit is not suitable for underground cabling. (Note: galvanised water pipe is acceptable and commonly used)</td>
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<tr>
<td>PVC conduit does not need to be earthed.</td>
<td>Steel conduit must be earthed.</td>
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4. INSTALLATION REQUIREMENTS

As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. Refer to the following requirements and AS/NZS 3000:2007 clauses:

- General Clause 3.10
- Clause 3.10.3.9
- Clause 3.9.9.3
- Clause 3.10.3.5
- Clause 3.9.8.3
- Clause 3.9.8.4

5. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- Earth resistance is safe and sufficiently low Clause 8.3.5
- Insulation resistance is safe and sufficiently high Clause 8.3.6
- Polarity is correct - including switches controlling active conductors Clause 8.3.7
- There is no transposition of earth and neutral conductors Clause 8.3.7
- There are no short circuits between conductors Clause 8.3.8
- There are no interconnections with another circuit Clause 8.3.8
- Verification of earth loop impedance Clause 8.3.9
- Operation of RCDs Clause 8.3.10
- Circuit control and protection devices on the main switchboard are correctly marked to indicate:
  - corresponding active and neutral conductors for each circuit Clause 2.9.5
  - relationship of equipment and the various parts of the installation
- IP rating of the accessories is maintained. Appendix G
- The earthing conductor included in the conduit only connects to earth of equipment supplied by active conductors contained in the conduit.
- Wiring enclosures are adequately supported and all covers are fitted.
TPI IN NON-METALLIC ENCLOSURES

PURPOSE:

In this section you will develop your skills in using thermoplastic insulated cables in non-metallic conduit & trunking

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

• Determine the Australian Standards requirements for the installation of non-metallic enclosures

• Cut and set rigid non-metallic trunking and conduit and accessories

• Install circuits using TPI cables in non-metallic enclosures

• Test circuits to ensure they are safe and operate as intended.

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

• AS/NZS 3000:2007

• Hampson, Jeffery, *Electrotechnology Practice*, Section 10 pgs 324 – 364 Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students on an individual basis.
1. **JOB SPECIFICATION**

1. The installation of a **two lighting points** using single insulated PVC cable in PVC enclosures, controlled by a **two way switching**.

2. The fixed wiring is to originate from the switchboard,

3. The circuit must be protected by an appropriate **RCD** circuit breaker for the circuit and the fixed wiring is to originate from the switchboard.

**Lighting circuit cable size ________________ Size of circuit breaker ____**

**All work to be carried out to comply with AS/NZS 3000 Installation Rules**
3. MATERIAL LIST

1. List the materials needed to install the lighting final sub-circuit and enter in table 1

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</table>
4. LIGHTING CIRCUIT

1. Complete the wiring diagram for the lighting points controlled by a two way switch.

![Diagram of lighting circuit]

*Note: Using TPI in conduit, the neutral and earth conductors can be wired directly to the lights and don’t need to go through the switches.*
5. SWITCHBOARD

1. Complete the wiring diagram for the lighting circuit protected by an MCB/RCD.

6. BOARD LAYOUT
NOTES

******
TPI IN NON-METALLIC ENCLOSURES

These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.

1. What is the minimum size earth conductor which can be used when using 1 mm² single insulated active and neutral (TPI) cable in conduit or duct?
   __________________________________________
   __________

2. When bending Light duty rigid PVC conduit, what precautions should be observed?
   __________________________________________
   __________

3. By what marking or identification are PVC conduits labelled when the PVC conduit material is suitable for installation in exposed direct sunlight?
   __________________________________________
   __________

4. If rigid non-metallic conduit is installed in a roof space of a factory:
   a. PVC jointing cement must be used
   b. provision must be made for expansion
   c. the conduit must have the rating ‘T’
   d. the maximum size is 40 mm
   AS/NZS 3000 reference ___________________

5. To connect medium duty rigid PVC conduit to an accessory or appliance that has threaded conduit entries, you should:
   a. cut a thread on the PVC conduit with a suitable stock and die
   b. file away the thread until you can fit the conduit into the access hole and glue it in place
   c. fit the conduit through the hole and seal the hole with silicon or similar sealing compound
   d. attach a plain to screw adaptor to the conduit with a thread that is the same as the accessory
6. List the most common colour for the following conduits.
   a. Medium duty rigid PVC ____________________
   b. Heavy duty rigid PVC ____________________
   c. Underground telecommunications ____________________

7. Answer review questions 1-15 on page 343 of your textbook-
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TPI IN METALLIC ENCLOSURES

PURPOSE:

In this section you will develop your skills in using thermoplastic insulated cables in metallic conduit and trunking

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of metallic enclosures
- Install circuits using thermoplastic insulated cables in metallic conduit & trunking.
- Cut, thread & set metallic conduit
- Fit metallic conduit to metallic trunking and accessories.
- Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 324 -364, Pearson Education Australia. French’s Forest NSW 2086
1. INTRODUCTION

When installation conditions require extra protection from ___________ damage, it is normal to use ___________ enclosures. Electricians working in the lift industry or working on plant that require explosion proof installations use steel conduit extensively.

This section will deal with the basic skills needed to install a basic steel conduit or other metallic wiring system.

Metallic enclosures provide cable protection from _______ and _______. They are also suitable where the ambient temperature exceeds the limits for _______ enclosures.

It should be noted that the cable being enclosed in Metallic enclosures has insulation generally made from _______ and thus still liable to damage from ______________ heat.

There are some situations where a metallic wiring enclosure may need extra protection:

- Where exposed to corrosive fumes
- Salt laden atmospheres
- Exposed to weather
- In contact with certain types of concrete

Metallic cable trunking is unsuitable in _________ situations, because of its removable lid or in areas exposed to the possibility of ________________ damage. It is generally made from light gauge sheet metal.

Metallic enclosures are generally protected by painting them inside and out or, if steel, hot dip galvanized inside and out.
1. **Steel conduit** is available from **16 mm up to 50 mm diameter**. Most steel conduit from suppliers is **galvanised** to protect against corrosion. Other metallic piping can be used in place of steel conduit providing it affords adequate ________________ and ________________ continuity. Steel conduit provides up to **10 times the** (tensile) strength of PVC conduit

2. **Steel or aluminium trunking** is readily available, steel being the most common type, made from folded galvanised sheet steel. *(See figure 10.142 on page 358 in your textbook)*

3. **Accessories for trunking.** Pre-fabricated trunking **tees, elbows and joining sections** are commonly available, as in PVC trunking.

4. **Accessories for steel conduit.** A similar range of accessories, as used with PVC conduit systems, such as **junction boxes, tees and elbows** is available for steel conduit systems. *(See figure 10.70 on page 329 in your textbook)*

### 3. INSTALLATION OF METALLIC CONDUITS

- Conduit must be free from internal __________ and ___________. *(3.10.3.5b)*
  This means it is best to cut conduit to length using a **hacksaw** as the **burr** produced is easily **removed by filing** or with a **de-burring tool. See figure 10.100 on page 345 in your textbook**

- Any sets or bends in the conduit must not _________ - the walls or open any joints or welds. Unlike PVC conduit, which may be set by hand or across the knee, **steel conduit requires** the use of **commercial or automatic bending machines**

*(See Pictures on page 343-356 in your textbook)*
You must cut a __________ to join metallic conduits or terminate the pipe at an appliance or accessory. Any damage to the protective coating on the pipe means you must replace the pipe. Damage can occur while gripping the conduit for threading, as well as when cutting the thread itself.

**Fixed stocks and block dies** are the most common way of **hand threading steel conduit**.

The ends of the conduit must be **de-burred to prevent cable damage**.

![Warragul single block stock and die](image1)

![End of conduit after deburring](image2)
BENDING STEEL CONDUIT

With the conduit on the ground fit the bender so the datum (end of the die) lines up with the first bending point, grip the handle, place your feet as shown and draw the handle of the bender upwards.

Draw the handle of the bender upwards until it is vertical. The first bend is complete.

Lift the conduit, with the bender attached, from the ground, and turn the assembly over so that the handle is facing downwards. Rotate the conduit 180° and align the second bending mark. Take care that the loose end of the conduit doesn’t cause injury or damage to people or property.

Tilt the bender forward, and secure the handle from slipping with your foot. Force the conduit down and around the bender making sure it follows the radius of the die. Only bend the conduit enough so that the stem will clear the ground when you finish the bend on the ground.
4. SUPPORT (Saddles)

The supports for the rigid metallic systems can be **further apart than for PVC conduit**. Supports for metallic conduits must be placed to prevent damage to _______ or and any associated _______. Linear expansion is also less of a problem. **Flexible metallic conduit**, on the other hand, needs **supports more closely spaced** than flexible PVC conduit.

5. FITTINGS

All fittings for conduit should be of the _____________ type except in certain cases. The inspection cavity makes it easier to _______ in the cable. The fitting must maintain electrical ______________ and hold the conduit without distorting it.

6. CONTINUITY AND EARTHING

All steel conduits and trunking systems must be earthed for their entire length, except where they contain only double insulated cabling. AS/NZS 3000:2007 allows use of the steel conduit or trunking itself as an earth conductor, if specific installation methods are satisfied. **The safest method is to run a green/yellow earthing conductor inside the metallic enclosure** to earth appliances supplied from the cabling enclosed in the conduit or trunking.

Where the lengths of trunking are securely bolted or riveted together to supply a high quality mechanical and electrically continuous joint, **earthing connection** to the trunking system takes place **close to the switchboard**.

The same is true with steel conduit runs, joined by threaded or screwed connections.
Non-metallic fittings.
At any point where the metal enclosure is not mechanically and electrically continuous, the parts must be electrically joined by installing an earthing connection between them. You must be careful to maintain ___________ and ___________ continuity when using metallic wiring enclosures. If a _________________ housing or junction box interrupts the continuity of the wiring enclosure, you must bond the two parts of the metallic enclosure to ensure electrical continuity.

Maintaining electrical continuity of a metallic conduit run

7. AS/NZS 3000 INSTALLATION REQUIREMENTS
As well as the circuit operating in a manner that satisfies the customer, the installation must also satisfy all requirements of AS/NZS 3000:2007. Write the key points from the following AS/NZS 3000 clauses in the space below:

Clause 3.10
Clause 3.10.3.9
Clause 3.9.8.3
Clause 3.9.8.4
Clause 5.3.2.2
Clause 3.10.3.5
Clause 5.5.3.2
8. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- **Earth resistance is safe and sufficiently low**  
  Clause 8.3.5
- **Insulation resistance is safe and sufficiently high**  
  Clause 8.3.6
- **Polarity is correct - including switches controlling active conductors**  
  Clause 8.3.7
- **There is no transposition of earth and neutral conductors**  
  Clause 8.3.7
- **There are no short circuits between conductors**  
  Clause 8.3.8
- **There are no interconnections with another circuit**  
  Clause 8.3.8
- **Verification of earth loop impedance**  
  Clause 8.3.9
- **Operation of RCDs**  
  Clause 8.3.10
- **Circuit control and protection devices on the main switchboard are correctly marked to indicate:**  
  Clause 2.9.5
  - corresponding active and neutral conductors for each circuit
  - relationship of equipment and the various parts of the installation
- **IP rating of the accessories, if any, is maintained.**  
  Appendix G
- **The earthing conductor included in the enclosure only connects to earth of equipment supplied by active conductors contained in the enclosure**
- **Joins in conductors are suitably enclosed**
- **Wiring enclosures are adequately supported**
- **All covers are fitted**
- **Electrical continuity of metallic enclosures is maintained**
- **Enclosures are solidly bonded to earth**
- **Protective coatings are intact**
TPI IN METALLIC ENCLOSURES

PURPOSE:

In this section you will develop your skills in using thermoplastic insulated cables in metallic conduit and trunking

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of metallic enclosures
- Install circuits using thermoplastic insulated cables in metallic conduit & trunking.
- Cut, thread & set metallic conduit
- Fit metallic conduit to metallic trunking and accessories.
- Test circuits to ensure they are safe and operate as intended.

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 324 - 364, Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students on an individual basis.
1. **JOB SPECIFICATION**

1. The installation consists of a two lighting points controlled by one switch in a steel enclosure.

2. The installation of a socket outlet in a metal enclosure, all wiring is to originate from the switchboard.

**All work to be carried out to comply with AS/NZS 3000 Installation Rules**

*Your teacher will give you the dimensions for your job*

![Diagram showing the electrical layout of the installation]

Lighting circuit cable size ________________ Size of circuit breaker _____

Power circuit cable size ________________ Size of circuit breaker _____
2. MATERIAL LIST

1. List the materials needed to install the lighting final sub-circuit and enter in table 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Description</th>
<th>Quantity</th>
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<tr>
<td>15</td>
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</tbody>
</table>
3. LIGHTING CIRCUIT

1. Complete the wiring diagram for the light controlled by an individual switch

![Wiring Diagram](image-url)
4. SWITCHBOARD WIRING

![Diagram of crossover links for switchboard with earthing (E), neutral (N), and RCD neutral (RCDN) connections.](image)
TPI IN METALLIC ENCLOSURES

These questions will help you revise what you have learnt in Section]. Write down the
AS/NZS 3000:2007 reference with each answer when it is used.

1. Galvanised steel conduit is commonly available in what size ranges?
   __________________________________________________________

2. What is the standard measurement for a length of steel conduit?
   __________________________________________________________

3. The size of steel conduit is measured by its internal or external diameter?
   __________________________________________________________

4. When bending steel conduit, what precautions should be observed?
   __________________________________________________________
   __________________________________________________________ AS/ NZS3000

5. Where must a run of steel conduit be earthed?
   __________________________________________________________
   __________________________________________________________ AS/ NZS3000

6. After threading steel conduit what should be removed?
   __________________________________________________________
   __________________________________________________________ AS/ NZS3000

7. If a run of steel conduit is interrupted by a PVC switch, what precautions should be observed?
   __________________________________________________________
   __________________________________________________________ AS/ NZS3000
8. If you are required to change wiring enclosures, is the switchboard a suitable place to change enclosures?

______________________________________________________________________________

AS/ NZS3000

9. When running steel conduit vertically how far apart are the supports by installed?

______________________________________________________________________________

______________________________________________________________________________

AS/ NZS3000

10. When installing single insulated cables in steel conduit, care should be taken not to:

______________________________________________________________________________

11. Answer questions 1 -12 on page 357 of your textbook

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
FIRE PROTECTION CABLEING AND SYSTEMS

PURPOSE:

In this section you will develop your skills in using mineral insulated metal-sheathed (MIMS) cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of fire protection cable and mineral insulated metal sheathed cables.
- Describe the requirements when passing a wiring system through a fire rated wall or floor
- Recognise different fire protection cable types including Pyrolex, Radox and MIMS.
- Terminate fire protection cable using correct termination procedures.
- Install circuits using fire protection cable
- Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, *Electrotechnology Practice*, Section 10 pgs 310 -311, Section 11 pgs 406 -407, Pearson Education Australia. French’s Forest NSW 2086
1. FIRE AND / OR HEAT RESISTANT CABLES

Cables discussed in this section are:

- Heat resistant,
- Fire resistant or
- Heat and fire resistant cables.

TPS (PVC) insulation is typically rated to operate within 75° (_______) or 90° (_______) maximum temperatures. PVC burns easily (but is self extinguishing). The problem is PVC produces smoke containing hazardous chemicals and toxic gases when burnt (hydrogen chloride gas, hydrochloric acid and halogens). So TPS cable is not suitable for heat or fire resistant applications.

Student exercise 1:

Fill in the applications for the following Heat/ fire resistant cables in the table below.

(See Section 11 pgs 406 -407 in your textbook)

<table>
<thead>
<tr>
<th>Cable</th>
<th>Application</th>
<th>Heat resistant</th>
<th>Fire resistant</th>
</tr>
</thead>
<tbody>
<tr>
<td>V105PVC</td>
<td></td>
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<tr>
<td>Glass fibre insulated cables</td>
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<tr>
<td>MIMS</td>
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<td>Radox</td>
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<tr>
<td>Pyrolex</td>
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<tr>
<td>See also ‘Firestop’ cables (see web link below)</td>
<td></td>
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</tbody>
</table>
Radox and Pyrolex are prone to ______________ damage and provide less integrity in case of fire. Mineral Insulated Metal Sheathed (_______) cable is less flexible and more difficult to install however when there is a need to maintain circuits (fire pumps, emergency lighting, passenger lifts etc) during a fire it is a suitable choice.

2. FIRE PERFORMANCE RATING TESTS

In considering the degree of cable performance required in fire, the properties of the cable ______________ are established by controlled laboratory tests.

- Ignition test: determines how easily the insulation will ignite.
- Flame propagation test: tests the time taken for a cable sample to self-extinguish after the source flame has been removed.
- Gaseous emission test: measures the amount of acidic gas released during the burning of a cable sample.
- Smoke emission test: measures the smoke density of a burning sample of cable.
- Circuit integrity test: measures the ability of a circuit to continue operation at a specified temperature and length of time.

3. MINERAL INSULATED METAL SHEATHED CABLE (MIMS)

(See Figure 10.30 on page 310 in your textbook) and http://www.pyrosales.com.au/files/grabdoc.php?type=doc&id=746

This type of cable consists of an annealed seamless metal sheath, housing a highly compressed mineral oxide powder (magnesium oxide), which surrounds and insulates between 1 to 7 ________ conductors. The most common material used for the outer sheath of MIMS cables is __________. The melting point of copper (1080°C approximately) and magnesium oxide (2800°C) means MIMS cable is virtually “____________”.

See Web links:

An example of this property occurred in the Rail Tunnel between the United Kingdom and France in 1996 when a fire broke out. The temperatures reached destroyed concrete and welded rail. The MIMS cable used for the emergency lighting ensured they functioned allowing the safe evacuation of passengers and crew.

Copper and Magnesium Oxide are both______________ and won’t produce any toxic smoke or gas.

Copper, although mostly inert, is affected by agents in concrete and plaster so if the cable is to be buried in concrete or plaster it should have a **protective [____________ serving]**. Similar restrictions apply to MIMS cables installed underground to avoid _____________ on the metallic sheath of the cable.

Compressed **magnesium oxide powder** insulation is **Hygroscopic**, that is, it will _____________ moisture readily.

Mineral insulated metal sheathed cable provides an **alternative to wiring systems in metallic conduit**. This method may be more expensive than TPI cables and conduit but is generally quicker to install.

The annealed seamless **copper sheath** be used as an earth conductor, saving money on larger systems.

Current can be carried up to a cable temperature of 1000°, the melting point of the copper sheath.

The cable is most likely to fail at its _____________.

4. **CONDUCTOR SIZE**

The smallest conductor size used for fixed wiring is 1 mm² and this applies to most wiring systems. The largest **solid** conductor for fixed wiring is 2.5 mm² except for MIMS cables and a few other cases. MIMS cables __________ have any stranded conductors and the maximum number of cores in the cable is __________. MIMS cable is available from 1mm² up to very large single core cables e.g. 400mm².

Clause 5.3.2.1.1(c) of AS/NZS 3000:2007 precludes you from using a solid conductor less than __________ as an earthing conductor. However, the sheath of the cable is suitable for use as the earthing conductor.
5. **EARTH SHEATH RETURN SYSTEM (ESR)**

In installations using the MEN system of earthing, it is possible to **combine the neutral and the earthing conductors** - ______________________. This is an economical system often used in multi-storey construction; Clause 3.16 of AS/NZS 3000:2007 provides information about the **Earth Sheath Return system** (ESR).

6. **SUPPORT AND FIXING**

Spacings between fixings and supports for MIMS cables should be such to protect the cable from ____________.

One feature of MIMS cables in operation is the relatively high surface temperature of the metallic sheath under some conditions. You should install the cable in such a way as to avoid ____________ to other sections of the electrical installation that may suffer damage at these higher temperatures.

MIMS cable has the following limitations:

- **Bend radius:** See AS/NZS 3000, clause 3.9.6
- **Operating temperature limits:** See AS/NZS 3000Clause 3.4.2 - table 3.2, note 5

7. **TERMINATIONS**

Terminating MIMS cables is a specialised job that requires **specialised tools** and equipment. The main purpose of the termination accessories is to prevent ____________ from entering the cable insulation and the _______ of the powdery magnesium oxide insulation.

*Before starting it is best to straighten the cable for the length to be stripped.*

8. **SERVING**

If the cable is PVC served it must be removed for the length of tail required plus the length of pot and gland. Remove it with a knife before stripping the sheathing.
9. **TOOLS FOR STRIPPING**

1. **Pyrotenax “Sheathmaster”**
   - The end of the cable should be square to begin. Use a fine toothed hacksaw.
   - Insert the cable and tighten enough to allow the tool to rotate on the cable.
   - Adjust the blade position. It should be set half way between the sheath and the conductors.
   - Hold cable with pliers or multi grips
   - Rotate the tool clockwise up to the pliers to achieve a square end.

2. **Stripping rod**
   - Fit the slot to a tag of sheath, lifted with side cutters.
   - At an angle of 45°, wind the rod, while twisting, around the cable.

3. **Side cutters**
   - Slow
   - Use in similar fashion to rod.
The amount of sheath stripped should allow for correct termination of the cable.

Thoroughly clean the conductors with a clean, dry cloth, scourer or wire brush. All Magnesium Oxide must be removed to prevent moisture tracking along the conductors, leading to termination failure.

10. **INSULATION RESISTANCE**

The insulation resistance should be checked **after stripping and before termination**. It should be greater than ____________. This will prevent a lowering of the total circuit resistance when a number of cables are to be installed.

11. **MOISTURE REMOVAL**

Moisture is ____________ when the cable is open to the environment through a chemical reaction between the Magnesium oxide and water. Typically it won’t penetrate much further than 400 to 600 mm. The first 25 mm becomes moist quickly. Any moisture **must** be removed before the cable is sealed as this will affect the insulation resistance.

**To locate moisture:**

- Place an I.R. tester lead on 1 conductor with the second lead attached to the cable sheath.
- Heat, using a “soft” gas flame about 1 metre from the end.
- As the moisture heats it boils and the resistance reading will drop toward zero.

**To remove moisture:**

- Heat the cable until the sheath starts to change colour and slowly move the flame toward the end.
- The insulation should increase as the moisture is “boiled” off.
12. TERMINATING MIMS CABLE

*(See Figure 10.31 on page 311 in your textbook)*

1. Cut cable square and slide the gland onto the cable.
2. Strip the cable. Use pliers to stop at the required position.
3. Clean the conductors and screw the pot seal onto the sheath.
4. Tap the cable to remove excess powder. Fill the pot completely with sealing compound.
5. Assemble the stub cap and compress the compound. Crimp the pot to completely seal.
6. Test conductors for continuity then fit the conductor sleeving. Test IR.

Crimping Tool used to insert the pot seal into the Pot.

13. GENERAL INSTALLATION TIPS

- Expansion/vibration bends are required to avoid fracture in situations where vibration is a factor.
- Re-anneal if copper becomes work hardened (heat to cherry red and cool in air)
- Use correct tooling (rollers) to remove bend and kinks before installation.
14. FIRE INTEGRITY

*Read ‘Fire integrity’ on page 407 in your textbook.

For further information refer to AS/NZS 3000 clause 4.2.2.6, and Building codes Australia.

When cutting or drilling holes through a fire rated wall or floor to install electrical equipment and accessories the fire integrity of the wall or floor must be maintained by:

- **Keeping hole sizes to a minimum** and:
- **Filling any gaps** around the electrical conduit or duct with an approved fire resistant putty or filler.


15. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- **Earth resistance is safe and sufficiently low** Clause 8.3.5
- **Insulation resistance is safe and sufficiently high** Clause 8.3.6
- **Polarity - including switches controlling active conductors** Clause 8.3.7
- **There is no transposition of earth and neutral conductors** Clause 8.3.7
- **There are no short circuits between conductors** Clause 8.3.8
- **There are no interconnections with another circuit** Clause 8.3.8
- **Verification of earth loop impedance** Clause 8.3.9
- **Operation of RCDs** Clause 8.3.10
- **Circuit control and protection devices on the main switchboard are correctly marked to indicate:** Clause 2.9.5
  - corresponding active and neutral conductors for each circuit
  - relationship of equipment and the various parts of the installation
NOTES

******
FIRE PROTECTION CABLING SYSTEMS

PURPOSE:
In this section you will develop your skills in using mineral insulated metal-sheathed (MIMS) cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:
At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of fire protection cable and mineral insulated metal sheathed cables.
- Describe the requirements when passing a wiring system through a fire rated wall and floor
- Recognise different fire protection cable types including Pyrolex, Radox and MIMS.
- Terminate fire protection cable using correct termination procedures.
- Install circuits using fire protection cable
- Test circuits to ensure they are safe and operate as intended.

EQUIPMENT:
The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 310 – 311, Pearson Education Australia. French’s Forest NSW 2086

NOTE:
This practical segment is to be completed by students on an individual basis.
1. JOB SPECIFICATION

1. The installation consists of two lighting points controlled by one switch in a PVC conduit and MIMS Cable

All work to be carried out to comply with AS/NZS 3000 Installation Rules

The fixed wiring is to originate from the switchboard.

The cable size for the lighting circuit ______________

The size of circuit breaker for the lighting circuit ____________
MATERIAL LIST

1. List the materials needed to install the lighting final sub-circuit and enter in table 1

<table>
<thead>
<tr>
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<th>Quantity</th>
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LIGHTING CIRCUIT

1. Complete the wiring diagram for two lights controlled by an individual switch.

![Diagram of two lights controlled by an individual switch]

SWITCHBOARD

1. Complete the wiring diagram for the switchboard, using RCD circuit protection

![Diagram of switchboard with RCD circuit protection]
BOARD LAYOUT
FIRE PROTECTION CABLEING SYSTEMS

These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.

1. Mineral Insulated Metal Sheathed cable consists of a seamless copper sheath, with what powder as the insulator?

____________________________________________________________________

2. How is MIMS cable defined as per the AS3000 wiring rules?

____________________________________________________________________

____________________________________________________________________

_____________________________________________ AS/ NZS 3000 __________

3. What is the maximum operating temperature of MIMS cable?

_____________________________________________ AS/ NZS 3000 __________

4. How should MIMS cable be supported?

_____________________________________________ AS/ NZS 3000 __________

5. Is it permissible to use plastic saddles to fix MIMS cable?

_____________________________________________ AS/ NZS 3000 __________

6. When terminating MIMS cable to a motor, what should be provided to stop vibration?

_____________________________________________ AS/ NZS 3000 __________

7. Is it permissible to install orange served MIMS cable buried directly in the concrete without any further protection?

_____________________________________________ AS/ NZS 3000 __________

8. Are you permitted to use orange served MIMS cable in a refrigeration room?

_____________________________________________ AS/ NZS 3000 __________
9. Can MIMS cable be used as an Earth Sheathed Return system?

_____________________________________________ AS/ NZS 3000

10. What type of MIMS cable is suitable for underground wiring?

_____________________________________________ AS/ NZS 3000

11. Answer questions 7 & 8 on page 320 of your textbook

____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________

NOTES

******
STEEL WIRED ARMOURED CABLES

PURPOSE:
In this section you will develop your skills in Steel Wired Armoured (SWA) cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:
At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of SWA cable
- Identify a range of accessories used with SWA cables
- Install circuits using SWA cables.
- Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, Electrotechnology Practice, Section 10 page 314, Pearson Education Australia. French’s Forest NSW 2086
1. INTRODUCTION

*See figure 10.38 on page 314 of your textbook and samples of SWA cables provided by your teacher.

Steel wire armoured cables (_______) are sometimes used as alternatives to wiring systems in __________ conduit, that is, where ______________ protection is required. These methods are generally more expensive than TPI cables in conduit but they are generally quicker to install.

1. STEEL WIRE ARMOURED CABLE

Armoured cables have the advantage of a _________ wrapping that surrounds the cores of the cable with the wrapping itself being protected by a PVC sheath.

The metallic armour is for mechanical protection and is not a _______________.

Do not confuse this cable with neutral screened cables. You can use the armour of the cable for ________________.

The fittings or cable glands used with this type of cable must be capable of making an ___________ electrical connection to the steel armour. Some glands will also make a weatherproof seal with the sheath of the cable.

The extra protection offered by the steel armour lets you install this cable ______________ in situations that might otherwise need the protection of conduit.

2. SUPPORT OF SWA CABLES

The same regulations for the support of unarmoured cables apply to armoured cables.

The cables must have sufficient support to prevent undue ___________. When SWA cable is run vertically, the supports need to be closer together than for unarmoured cables. The extra support is necessary because the armoured cable is much ________ than the unarmoured cable of similar size.
3. FITTINGS TO TERMINATE SWA CABLES

Weatherproof Gland for SWA PVC Sheathed cable

4. INSTALLATION REQUIREMENTS

SWA cables must comply with AS/NZS 3000 and the circuit must operate in a manner that satisfies the customer. Refer to the following requirements and AS/NZS 3000 clauses:

Clause 1.4.18
Clause 3.9.7.2
Clause 3.9.6
Clause 5.3.2.2
Clause 5.5.3.2
5. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- **Earth resistance is safe and sufficiently low** Clause 8.3.5
- **Insulation resistance is safe and sufficiently high** Clause 8.3.6
- **Polarity is correct - including switches controlling active conductors** Clause 8.3.7
- **There is no transposition of earth and neutral conductors** Clause 8.3.7
- **There are no short circuits between conductors** Clause 8.3.8
- **There are no interconnections with another circuit** Clause 8.3.8
- **Verification of earth loop impedance** Clause 8.3.9
- **Operation of RCDs** Clause 8.3.10
- **Circuit control and protection devices on the main switchboard are correctly marked to indicate:** Clause 2.9.5
  - corresponding active and neutral conductors for each circuit
  - relationship of equipment and the various parts of the installation
SWA CABLES

PURPOSE:

In this section you will develop your skills in Steel Wired Armoured (SWA) cables.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

• Determine the Australian Standards requirements for the installation of SWA cable
• Identify a range of accessories used with SWA cables
• Install circuits using SWA cables.
• Test circuits to ensure they are safe and operate as intended.

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

• AS/NZS 3000:2007
• Hampson, Jeffery, Electrotechnology Practice, Section 10 pgs 314, Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students on an individual basis.
1. JOB SPECIFICATION

a) The installation consists of a lighting point controlled by one switch in a steel conduit

b) The installation of a socket outlet in a steel wired armoured cable

c) The lighting and power are supplied from the one circuit (mixed circuit)

All work to be carried out to comply with AS/NZS 3000 Installation Rules

The fixed wiring is to originate from the switchboard.

The cable size for the mixed circuit = __________ mm$^2$

The size of circuit breaker for the mixed circuit = _____ A
2. MATERIALS LIST

List the materials needed to install the lighting final sub-circuit and enter in table 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Item Description</th>
<th>Quantity</th>
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</table>
3. **LIGHTING CIRCUIT**

1. Complete the wiring diagram for the light controlled by an individual switch.

![Lighting Circuit Diagram]

4. **POWER CIRCUIT**

1. Complete the wiring diagram for the socket outlet.

![Power Circuit Diagram]
5. SWITCHBOARD

1. Complete the wiring diagram for the switchboard, using RCD circuit protection

![Diagram of switchboard wiring](image)

Mixed circuit

6. BOARD LAYOUT

![Diagram of board layout](image)
SWA CABLES

These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.

1. How is Steel Wired Armoured cable defined?
   _______________________________________________________________________
   AS / NZS3000

2. If the steel armouring of steel wired armoured cable, needs to be earthed where should it be earthed?
   _______________________________________________________________________
   AS / NZS3000

3. Can SWA cable be installed directly in a concrete slab, without any further protection?
   _______________________________________________________________________
   AS / NZS3000

4. What is the minimum depth in the ground of steel wired armoured cable installed underground in a category A system?
   _______________________________________________________________________
   AS / NZS3000

5. Is it permissible to install SWA cable buried directly in the ground without any further protection?
   _______________________________________________________________________
   AS / NZS3000

6. What is the minimum bending radius for 25 sq mm, 4 core, SWA cable? (the overall diameter of the cable is 30 mm)
   _______________________________________________________________________
   AS / NZS3000

7. When joining SWA cables the steel armouring what are the requirements for the armouring?
   _______________________________________________________________________
   AS / NZS3000
8. When installing SWA cable on a vertical wall, what can be used to fix the cable to the wall?

_____________________________________________ AS / NZS3000

9. What is maximum operating temperature of V75 PVC sheathed SWA cable?

_____________________________________________ AS / NZS3000

NOTES

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TRAILING CABLES AND CATENARY SYSTEMS

PURPOSE:
In this section you will develop your skills in using trailing cables, catenary wiring and pendant sockets.

TO ACHIEVE THE PURPOSE OF THIS SECTION:
At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of trailing cables and catenary wiring
- Identify a range of equipment used with trailing cable and catenary systems
- Install a catenary wiring system.
- Install a trailing cable system supplying a pendant socket outlet.
- Test circuits to ensure they are safe and operate as intended.

REFERENCES:

- AS/NZS 3000:2007
1. Catenary Systems

Catenary support systems for TPS cables and other aerial support systems find use in a variety of installations from building sites to supermarkets and factories. These systems are often used where cables have to ______ an area that is in __________ use but still maintain high levels of _____________________. One typical application for a catenary support system is for the ______________ power to a site shed on a construction site.

*See also figure 10.41 on page 315 in your textbook

A catenary is a wire, usually ____________________ used to support a TPS cable. The TPS cable must also have ________________ conductors and be attached to the catenary support in a way that does not ______________ the thermoplastic sheath. ________________ or clips can be used with tape wrapped around the catenary wire to prevent chafing between the strands of the catenary and the power cable sheath. The attachment points should be around __________ apart, to avoid undue sag.

Turnbuckles provide a way of straining the wire rope and provide a horizontal wire support for the cable ties. Wire rope thimbles anchor the support wires.

When placing the cable on the catenary you need to provide some slack in it to prevent strain on the cable. To prevent water from travelling along the cable and entering a building a __________ loop is normally provided.
2. **MINIMUM SAG**

The tensile strength of the catenary wire limits the length of span and loading on the catenary.

Excessive tension on the catenary may cause the wire to stretch and ultimately __________.

An allowance for wind and other extra loads, for example rain water, ice, birds etc, may be necessary because these will cause strain on the catenary that may be significant in some locations. Stranded catenary wire is used to allow ____________ under these circumstances.

Don’t overlook the strength of the supports for the catenary. You wouldn’t want the load on the catenary to pull away a section of the building supporting it. One way you can avoid excessive strain on the catenary is to provide an amount of sag in the catenary when you install the cable.

3. **CLEARANCE BETWEEN GROUND AND THE CATENARY**

- The minimum clearance height depends on the use of the area underneath. For example, you need a greater clearance for an area used by vehicles compared to an area used for pedestrian traffic only. Minimum clearances are specified in AS/NZS3000:2007, Table 3.8.

- The height of the supports for the catenary will be the sum of the minimum clearance above ground plus the sag in the cable. See Figure D1 (Appendix D) for a guide to the selection of suitable poles or posts and information about clearances, wire sag etc.
4. **EARTHING CONDUCTOR**

You can use the catenary wire as an earthing conductor provided it complies with the minimum standards for strength and conductivity.

(See clause: 5.3.2.3 (d))

5. **TRAILING CABLES**

One of the main differences between a trailing cable system and a catenary support system is the relative **movement** between the supporting system and the attached cable. The trailing cable system generally supports _______________ cables and provides a method for controlling ______________ when the supplied load ____________.

![Trailing cable system diagram](image)

The support for the power cable may be a tightly strained steel wire, a rolled or extruded section of steel or aluminium. The attachments between the support system and the power cable are manufactured __________ and ______________ systems.

The trailing cable must have insulation equal to ____________________ and attaches to the rollers with cable ties or other purpose made clamps. The number of fixings and rollers depends on the amount of loop sag that is practical when the cable is in the fully retracted position and the amount of weight each roller can support. The rollers are either metal or nylon with a metal support and axle.
6. INSTALLATION REQUIREMENTS

Clause 3.13

Clause3.13.3 and Table3.8

Clause 1.4.20, 3.9.7.4

Clause 3.7.2.8

Clause 4.4.4.4

7. SAFETY TESTING

You must test each circuit as outlined in AS/NZS 3000 Clause 8.3, before you connect it to the supply. This ensures the circuit is safe to use by showing:

- Earth resistance is safe and sufficiently low  Clause 8.3.5
- Insulation resistance is safe and sufficiently high  Clause 8.3.6
- Polarity is correct - including switches controlling active conductors Clause 8.3.7
- There is no transposition of earth and neutral conductors  Clause 8.3.7
- There are no short circuits between conductors  Clause 8.3.8
- There are no interconnections with another circuit  Clause 8.3.8
- Verification of earth loop impedance  Clause 8.3.9
- Operation of RCDs  Clause 8.3.10
- Circuit control and protection devices on the main switchboard are correctly marked to indicate:  Clause 2.9.5
  - corresponding active and neutral conductors for each circuit
  - relationship of equipment and the various parts of the installation
NOTES

*******
TRAILING CABLES AND CATENARY SYSTEMS

PURPOSE:

In this section you will develop your skills in using trailing cables, catenary wiring and pendant sockets.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- Determine the Australian Standards requirements for the installation of trailing cables and catenary wiring
- Identify a range of equipment used with trailing cable and catenary systems
- Install a catenary wiring system.
- Install a trailing cable system supplying a pendant socket outlet.
- Test circuits to ensure they are safe and operate as intended.

EQUIPMENT:

The equipment needed for this exercise will be determined by you as part of the exercise.

REFERENCES:

- AS/NZS 3000:2007
- Hampson, Jeffery, *Electrotechnology Practice*, Section 10 pgs 315 – 316, Pearson Education Australia. French’s Forest NSW 2086

NOTE:

This practical segment is to be completed by students in groups of two.
1. JOB SPECIFICATION

To install catenary wiring system and a trailing cable. The circuit will supply a suspended pendant socket outlet.

- **Team up with a student on the opposite side of the room.** Whilst on the floor fix the TPS cable to the catenary wire. Allow enough TPS cable to reach the switchboard at one end and terminate in a ceiling rose at the other end.

- **Lift the catenary and fix to the anchor points.**
  Remember to leave some sag. (Some sag is good as it reduces the tension on the anchor points.)

- **Create weather (drip) loops** at either end to prevent water running along the cable into the building etc.

- **Terminate the Catenary cable**, one end at the switchboard and the other at the ceiling rose.

- **Install a short catenary** across the front of the cubicle at the load end of the cable.

- **Install a movable pendant outlet** via a trailing cable (See the layout diagram).

- **Terminate the other end of the TPS trailing cable** at the ceiling rose.

- **Install Earth leakage and over current protection** for your circuit. **You decide** how you would like to achieve the protection and complete the switchboard diagram accordingly. Connect the circuit at the switchboard.

- **Test the circuit** and record readings in table 1.
2. JOB LAYOUT

Note: The fixed wiring marked ‘supply’ connects to the switchboard.

Size of cable for the power circuit using double insulated = _____ mm² cable

Size of circuit breaker for the power circuit using _____ mm² cable

**All work to be carried out to comply with AS/NZS 3000 Installation Rules**
3. MATERIALS LIST

1. List the materials needed to install the lighting final sub-circuit and enter in table 1

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<th>Item</th>
<th>Item Description</th>
<th>Quantity</th>
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4. SWITCHBOARD

1. Complete the wiring diagram for the switchboard, using RCD circuit protection
6. CIRCUIT TESTING

<table>
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<td>Earth Continuity Test</td>
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<tr>
<td>Meter Used</td>
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<tr>
<td>Insulation Resistance Test</td>
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<tr>
<td>Meter Used</td>
</tr>
<tr>
<td>Polarity Test (Socket Outlets) Using test resistors</td>
</tr>
<tr>
<td>Active – Earth (Ω)</td>
</tr>
<tr>
<td>Short Circuit Test</td>
</tr>
<tr>
<td>Meter Used</td>
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<tr>
<td>Circuit Operates correctly     Yes / No</td>
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</table>

Student’s Name :
Signature :
Mark /
These questions will help you revise what you have learnt in Section]. Write down the AS/NZS 3000:2007 reference with each answer when it is used.

1. How is a catenary wiring system defined?
   ____________________________________________________________________________
   ____________________________________________________________________________
   ____________________________________________________________________________ AS / NZS3000

2. Is it necessary to use galvanised bolts a catenary wiring system?
   ____________________________________________________________________________ AS / NZS3000

3. Is it permissible to use single pole switch to control a suspended socket outlet?
   ____________________________________________________________________________ AS / NZS3000

4. Is it permissible to use single insulated cable on a catenary wiring system?
   ____________________________________________________________________________ AS / NZS3000

5. What height above the ground, in an outdoor situation, frequented by vehicles, should a catenary wiring system be installed?
   ____________________________________________________________________________ AS / NZS3000

6. Is it permissible to use a TPS cable in a catenary system?
   ____________________________________________________________________________ AS / NZS3000

7. Is a flexible cord attached to a pendant socket classed as fixed wiring?
   ____________________________________________________________________________ AS / NZS3000
8. What is required to terminate each end of a catenary wire system?
_______________________________________ AS / NZS3000 __________

9. Is it permissible to use a knot in a flexible cord to secure a pendant socket outlet?
_______________________________________ AS / NZS3000 __________

NOTES
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