THE UNIVERSITY OF SYDNEY

SAFE WORK PROCEDURE

Use this form to document Safe Work Procedures for hazardous activities and processes. The information in your Safe Work Procedure (SWP) should be supported by a risk assessment.

Faculty/School:	Faculty of Science — School of Physics (SAIL Labs)		**Initial Issue Date: January 2026**
			Next Review Date: January 2027
SWP Reference Number:	SWP-A28-SAIL-218G-3sae-cms	**Version: 1.0**	**Version Issue Date: January 2026**
SWP Title:	Operation of 3SAE Combiner Manufacturing System (CMS) for Fibre Optic Glass Processing		
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List the Hazards and risk controls as per risk assessment		
Associated risk assessment reference:	**Hazards**	**Risk controls**
RA-A28-SAIL-218G-3sae-cms	High-temperature plasma operation (300°C to >3000°C)	- Plasma enclosed in processing chamber; safety interlocks verified functional before operation - Minimum 500mm exclusion zone during plasma operation - All flammable materials removed from 1-metre radius - Minimum 15-minute cooling period before accessing processing chamber - Never leave the system unattended during operation - Heat-resistant gloves available for handling components after processing
RA-A28-SAIL-218G-3sae-cms	Compressed air system at high pressure (6.2 bar / 90 psi)	- Pre-operation inspection of air lines, fittings and pressure gauge before every session - Emergency air shut-off valve tested before each session - Never use compressed air to clean clothing or skin, or direct it at any person - Eye protection mandatory when working with compressed air systems - Regular equipment inspections and maintenance
RA-A28-SAIL-218G-3sae-cms	Electrical systems (dual 24V 200W power supplies)	- RCD protection on mains supply, tested before use - Electrical components enclosed within equipment housing - Lockout/tagout for any maintenance requiring access to electrical components - Only qualified electrical personnel authorised to access internal electrical systems - Immediate shutdown and reporting of any unusual electrical behaviour
RA-A28-SAIL-218G-3sae-cms	Optical radiation from plasma and intense lighting	- Indirect viewing via camera systems only; direct viewing of plasma or molten glass is prohibited - Vision system verified functional before every operation - Emergency stop if vision system fails during operation - Regular breaks during extended operation sessions
RA-A28-SAIL-218G-3sae-cms	Sharp glass fibres, cleaved ends, and diamond cleaving	- Close-fitting safety glasses mandatory at all times - Use tweezers or fibre handling tools; no hand contact with freshly cleaved fibre ends - Sharps disposal container within arm's reach of work area

	blade	- Lockout equipment before accessing cleaver blade for replacement - Clean up glass debris with sticky tape or damp cloth, never by hand
RA-A28-SAIL-218G-3sae-cms	Vacuum system operation during partial vacuum processes	- Pre-operation inspection of vacuum chamber seals and O-rings - Interlocks prevent chamber opening under vacuum; never open until fully vented to atmospheric pressure - Hands and fingers clear of all sealing surfaces before vacuum initiation - Immediately abort and vent if unusual sounds or pressure readings detected
RA-A28-SAIL-218G-3sae-cms	Chemical hazards from electrode materials and cleaning agents	- SDS available for all chemicals used with equipment - Nitrile gloves mandatory when handling electrodes or cleaning chemicals - Electrode cleaning performed in well-ventilated area with eye protection - Hand washing required after handling electrodes or chemicals
RA-A28-SAIL-218G-3sae-cms	Ergonomic strain from precision work and prolonged operation	- Ergonomic workstation setup; monitor at eye level and 50-70cm distance - Regular micro-breaks during precision work - Maximum continuous operation time without a break: 1 hour
RA-A28-SAIL-218G-3sae-cms	Equipment complexity requiring high level of competency	- Mandatory manufacturer training and documented competency assessment before operation - Authorised users list maintained and enforced - Never operate alone as an inexperienced user; graduated supervision requirements apply - Annual refresher training
RA-A28-SAIL-218G-3sae-cms	Software and control system operation	- Hardware emergency stop independent of software, tested before each session - Custom programs validated on scrap fibre before use on valuable components - Safe shutdown procedure for software failure - User access controls to prevent unauthorised software changes

List resources required including personal protective clothing, chemicals and equipment needed

PERSONAL PROTECTIVE EQUIPMENT (PPE):
- Safety glasses (mandatory at all times): close-fitting design to prevent glass fragment entry; must be worn whenever handling optical fibres or operating equipment
- Heat-resistant gloves: must be available and used when handling any components after plasma processing (not for use during active operation near plasma)
- Nitrile gloves (recommended): for handling optical fibres (provides cut protection and dexterity); mandatory when handling electrodes or cleaning chemicals
- Laboratory coat or protective clothing: to protect against glass fragments and potential chemical splashes
- Closed-toe shoes (mandatory): no open-toed footwear permitted in laboratory

EQUIPMENT AND MATERIALS:
- 3SAE Combiner Manufacturing System (CMS-01-0100)
- PC with CMS control software, monitor (23" or 40" depending on configuration)
- Optical fibres for processing (125µm to 2mm diameter as required)
- Appropriate fibre holders for diameter being processed (250µm, 400µm, 700µm, 1000µm, 1500µm, 2000µm, 2500µm)
- End cap holders if performing end cap splicing
- Electrode cleaning kit (cleaning discs provided with system)
- Spare electrode sets
- Cleaning materials for fibre preparation (isopropanol, lint-free wipes)
- Thermal inspection camera (for verifying cool-down before handling)

SAFETY EQUIPMENT (must be present in laboratory):
- Fire extinguisher suitable for electrical fires (CO_2 or dry powder type) within 10 metres of equipment; location:

[specify]
- First aid kit including splinter removal tools; location: [specify]
- Emergency eyewash station; location: [specify]
- Sharps disposal container for glass waste; location: within arm's reach of work area
- Emergency stop button (integrated into CMS system)
- Compressed air emergency shut-off valve; location: [specify]
- Mains power isolator for CMS; location: [specify]
- Emergency contact numbers displayed prominently
- Equipment operation logbook
- Incident report forms

ENVIRONMENTAL REQUIREMENTS:
- Compressed air supply: 6.2 bar (90 psi), 126 L/min (4.5 cfm) minimum
- Electrical supply: dual 24V 200W power sources (mains supply with RCD protection)
- Adequate bench space: minimum 1 metre clearance on all sides of equipment
- Adequate lighting: minimum 500 lux at work surface
- Adequate ventilation: for heat dissipation and any electrode fumes
- Stable work surface: capable of supporting 75 kg equipment weight
- Ambient temperature control: equipment operates best in controlled environment

List step by step instructions or order for undertaking the task

CRITICAL SAFETY REQUIREMENTS - BEFORE OPERATING THIS EQUIPMENT:
- You MUST have completed manufacturer training and been assessed as competent
- You MUST be listed on the authorised users list
- You MUST complete ALL pre-operation safety checks before every session
- You MUST maintain a 500mm exclusion zone during plasma operation
- You MUST NEVER disable safety interlocks or protective systems
- You MUST NEVER leave the system unattended during operation
- You MUST NEVER touch components during or immediately after plasma operation
- You MUST NEVER operate if any safety system appears faulty

STOP - verify your authorisation:
- Have you completed 3SAE CMS manufacturer training? YES/NO
- Have you passed the competency assessment? YES/NO
- Are you listed on the authorised users list? YES/NO
- If you answered NO to any of these: DO NOT OPERATE - contact supervisor

Supervision requirements for new users:
- First 10 operations: direct supervision by experienced user required
- Next 20 operations: experienced user must be present in laboratory
- After 30 successful operations: may operate independently if competency maintained

SECTION 1 - PRE-OPERATION SAFETY CHECKS (MANDATORY - DO NOT SKIP): complete these checks EVERY TIME before operation. If ANY check fails, DO NOT USE - lock out and report to supervisor immediately.

Sign in to equipment logbook:
- Record your name, date, time, and type of operation planned
- Review previous entries for any reported issues
- Check that no maintenance or repair is scheduled

Visual inspection of equipment exterior:
- Check for any visible damage to equipment housing or enclosures
- Verify no cables or hoses are damaged, frayed, or kinked
- Check that all cable connections are secure
- Ensure no liquid spills or contamination on or near equipment
- Verify work area is clean and free of clutter
- If ANY damage found: DO NOT USE - lock out and report to supervisor

Check exclusion zone and clearances:
- Verify 500mm exclusion zone around equipment is clear

- Remove any flammable materials from 1-metre radius
- Ensure no obstructions to emergency stop button or exit routes
- Confirm adequate lighting for operation
- Check that fire extinguisher is accessible

Compressed air system checks:
- Verify compressed air supply is connected and secure
- Check pressure gauge reads approximately 6.2 bar (90 psi)
- Listen for any unusual hissing or air leaks
- Inspect visible air lines for damage or kinks
- Test emergency air shut-off valve (close and reopen to verify function)
- If pressure is incorrect or leaks detected: DO NOT USE - contact facilities/supervisor

Electrical system checks:
- Verify mains power is connected and RCD is functional (test RCD button)
- Check that no electrical cables show damage or exposed conductors
- Verify all equipment indicators show normal status
- Ensure emergency power isolation switch is accessible and functional
- If any electrical issues detected: DO NOT USE - contact supervisor/electrician

Emergency stop button test (CRITICAL):
- Press emergency stop button to verify it functions
- System should immediately cease all operations
- Reset emergency stop and verify system can restart normally
- If emergency stop does not function correctly: DO NOT USE - lock out and report immediately

Safety interlock verification:
- Verify that opening chamber door during operation triggers automatic shutdown (test with system in safe idle state)
- Check that all safety interlocks appear intact and functional
- If any interlock appears bypassed or faulty: DO NOT USE - report immediately

Software and control system check:
- Power on PC and CMS control system
- Verify software loads without errors
- Check that both camera views display correctly
- Verify all system status indicators show "ready" or normal state
- If software errors or camera failures: DO NOT USE - contact IT/supervisor

Vision system verification:
- Check both orthogonal camera views are clear and focused
- Verify telecentric lenses are clean (clean gently with lens tissue if needed)
- Test that monitor displays both camera feeds clearly
- Adjust monitor brightness/contrast if needed for viewing comfort
- If vision system not functioning: DO NOT USE - operation requires visual monitoring

Check sharps disposal and first aid readiness:
- Verify sharps disposal container is available and not full
- Confirm first aid kit location and check it contains splinter removal tools
- Note location of emergency eyewash station
- If safety equipment not available: obtain before proceeding

Personal protective equipment (PPE) verification:
- Put on safety glasses (close-fitting type)
- Confirm laboratory coat/protective clothing is worn
- Verify closed-toe shoes are being worn
- Have nitrile gloves and heat-resistant gloves readily available
- Never proceed without appropriate PPE

Final pre-operation check:
- All pre-operation checks completed satisfactorily? YES/NO
- Any safety concerns or unusual observations? Record in logbook
- If any concerns: consult with supervisor before proceeding
- If all checks passed: proceed to operation

SECTION 2 - EQUIPMENT STARTUP AND INITIALISATION:

Power-up sequence:
- Ensure PC and CMS software are running
- Verify compressed air supply is open and at correct pressure
- Allow system to complete initialisation sequence (typically 2-3 minutes)
- Watch for any error messages during startup
- Verify all system diagnostics show normal operation

Electrode inspection and installation (if required):
- Put on nitrile gloves before handling electrodes
- Open electrode chamber following software prompts or manual procedures
- Visually inspect electrodes for wear, damage, or excessive contamination
- If electrodes appear worn (consult manufacturer guidelines for wear limits): replace with spare set
- Ensure electrodes are correctly positioned and secured
- Close electrode chamber and verify secure closure
- Remove nitrile gloves after electrode handling (do not contaminate other surfaces)

Cooling system verification:
- Verify embedded electrode cooling system is functioning (check for coolant flow indicators if present)
- Listen for coolant pump operation (should be quiet and steady)
- Check for any coolant leaks around electrode assembly
- If cooling system not functioning: DO NOT proceed - contact supervisor/manufacturer

Calibration and alignment check (if required by procedure):
- Some processes may require alignment calibration
- Follow software prompts for automatic alignment procedures
- Verify pitch and yaw alignment systems are functioning correctly
- If manual alignment needed: use provided alignment fixtures and follow manufacturer procedures

SECTION 3 - FIBRE PREPARATION AND LOADING:

Select appropriate fibre holders:
- Choose fibre holders matching the diameter of fibres to be processed (250µm holders for standard single-mode fibres; 400µm, 700µm, 1000µm, 1500µm, 2000µm, 2500µm for larger diameter fibres)
- Install fibre holders in both left and right positioning stages
- Ensure holders are clean and properly seated

Prepare optical fibres:
- Ensure safety glasses are on before handling fibres
- Strip fibre coating if required using appropriate stripping tool (not while in CMS)
- Clean fibre ends with isopropanol and lint-free wipes
- If cleaving externally before loading: use proper cleaving technique to achieve clean end face
- Handle fibres only by coated sections when possible
- Use tweezers or fibre handling tools - avoid direct hand contact with glass sections

Load fibres into holders:
- Carefully position fibre in left holder first
- Secure fibre gently (avoid over-tightening which can damage fibre)
- Load second fibre into right holder (for splicing operations)
- For tapering operations: load single fibre as per procedure
- Verify fibres are properly seated and secured
- Check alignment visually through camera system

Position fibres using software control:
- Use X-Y-Z positioning controls to align fibres
- Bring fibre ends into view of both camera systems
- For fusion splicing: align fibre cores using automatic or manual alignment
- Achieve alignment resolution of <50nm in X and Y axes
- Verify alignment on both orthogonal camera views before proceeding
- Never attempt to adjust fibre position manually while system is powered

SECTION 4 - OPERATION - FUSION SPLICING (for tapering or cleaving, see sections 5 and 6):

Configure splice parameters:
- Select appropriate splice program from software library, OR create custom splice program specifying: arc power settings (based on fibre type and diameter), arc duration, pre-splice cleaning arc (if required), overlap distance, push distance during splice
- Save custom programs for repeatability
- Test new programs on scrap fibres before using on valuable components

Pre-splice arc cleaning (if required):
- Some fibre types benefit from pre-splice cleaning arc
- Software will prompt for this step if programmed
- Verify fibres remain aligned during cleaning arc
- Visual inspection via camera for any debris or contamination

Final pre-splice verification - STOP - safety verification before plasma activation:
- Hands clear of equipment? YES
- Exclusion zone clear? YES
- Fibre alignment correct? YES
- Splice parameters confirmed? YES
- Emergency stop accessible? YES
- If any NO answers: correct before proceeding

Initiate fusion splice:
- Click "Start Splice" or equivalent command in software
- PLASMA WILL NOW ACTIVATE - stand clear
- Monitor splice progress on both camera views
- Watch for: smooth approach of fibre ends, uniform heating and melting of glass, proper fusion at interface, absence of bubbles or voids
- Do NOT reach towards equipment during plasma operation

Post-splice monitoring:
- Software will automatically control plasma power and timing, fibre positioning and overlap, push force during fusion, and cool-down period
- Process typically completes in 10-60 seconds depending on fibre size
- Wait for "Splice Complete" confirmation before proceeding

Splice quality assessment:
- System automatically captures before/during/after images
- Visually inspect splice on monitor for: smooth, symmetrical splice junction; proper alignment (minimal core offset); absence of bubbles, voids, or cracks; appropriate splice geometry
- Use scanning function to measure splice diameter profile if needed
- Record splice quality in logbook (accept/reject decision)

Cool-down period (MANDATORY):
- DO NOT touch fibres or components for minimum 15 minutes after splice
- Software may display temperature information
- Use thermal inspection camera to verify components have cooled if immediate handling required
- Heat-resistant gloves do not provide complete protection immediately after >3000°C plasma
- Plan work to allow proper cooling time between splices

Remove spliced component:
- After confirmed cool-down, carefully release fibre from holders
- Use fibre handling tools (tweezers) to grip coated sections only
- Transfer to appropriate storage or testing fixture
- Dispose of any cleaved scrap fibres in sharps container immediately

If splice is rejected:
- Cleave out the failed splice section
- Prepare new fibre ends
- Repeat alignment and splicing process
- Document failure mode in logbook for quality tracking

SECTION 5 - OPERATION - FIBRE TAPERING (uses plasma to elongate fibre while reducing diameter; available modes: bidirectional, single-direction, or custom table-based tapering):

Select tapering mode and parameters:
- Bidirectional tapering: for symmetric tapers up to 150mm length
- Single-direction tapering: for asymmetric tapers up to 90mm length
- Table-based tapering: for custom taper profiles using syntax-based programming
- Define critical parameters: taper ratio (input diameter / output diameter), taper length, pulling speed profile, arc power profile, hot zone width (can be expanded in partial vacuum mode)

Load fibre for tapering:
- Secure fibre in both left and right holders with adequate length for taper
- Ensure sufficient fibre extends beyond holders to achieve desired taper length
- Position initial heat zone at correct starting location
- Verify load cell feedback system is functional (shows fibre tension)

Partial vacuum mode (if required) - for adiabatic tapers or wide heat zone processing:
- Verify vacuum chamber seals and O-rings are in good condition
- Close chamber and verify seal integrity
- Initiate vacuum pump following software procedure
- Monitor pressure gauge during evacuation; target pressure: [specify based on process requirements]
- Never open chamber while under vacuum
- Vacuum mode expands plasma heat zone up to 10x along fibre axis
- If unusual sounds or pressure readings: immediately abort and vent to atmosphere

Configure taper program:
- Use simplified LabVIEW GUI for standard tapers, OR create custom program using table-based tapering interface, OR import program from MATLAB/Excel if custom algorithm developed
- Software allows 20 adjustments per second for fibre platform positions (left and right), heat zone location, and arc power settings
- Validate program with simulation or test run before using on valuable fibre

Initiate tapering process - STOP - final safety check:
- Fibre secured properly? YES
- Taper parameters confirmed? YES
- If using vacuum: chamber sealed and pressure correct? YES
- Exclusion zone clear? YES
- Click "Start Taper" command
- PLASMA WILL ACTIVATE - stand clear of equipment

Monitor tapering process:
- Watch "Hot Imaging" live view of molten glass during tapering
- Monitor load cell feedback showing fibre tension
- Verify smooth, controlled pulling motion
- Watch for taper formation via camera views
- Typical taper time: several minutes depending on length and profile
- Do NOT interfere with process once started
- If any abnormal behaviour observed: use emergency stop immediately

Post-taper procedures:
- Process completes automatically when programmed taper profile achieved
- Software captures images and process data
- Cooling period MANDATORY: minimum 15 minutes before handling
- If in vacuum mode: software will prompt for controlled venting; allow chamber to return to atmospheric pressure; verify pressure equalised before opening chamber
- Use thermal camera to verify taper has cooled sufficiently

Taper quality verification:
- Use scanning function to measure taper diameter profile
- Compare measured profile to target specification
- Visual inspection for: smooth taper transition, absence of modulations or stress concentrations, symmetry (for bidirectional tapers), proper taper length
- Record taper quality data in logbook
- If taper meets specifications: proceed to removal
- If taper is defective: document failure mode and repeat process

Remove tapered fibre:
- After confirmed cool-down and quality verification, carefully release fibre from holders using fibre handling tools
- Support taper along entire length to prevent breakage
- Transfer to appropriate storage or next processing step
- Clean work area and dispose of scrap in sharps container

SECTION 6 - OPERATION - PRECISION CLEAVING (in situ ultrasonic diamond-tipped cleaving for production of end caps, tapers, and accurate length components):

Prepare fibre for cleaving:
- Load fibre to be cleaved in appropriate holder
- Position fibre so desired cleave location is in field of view
- Use real-time scanning to identify exact cleave position
- Achieve cleave location precision of ±12.5µm using reference marks

Configure cleaving parameters:
- Diamond-tipped blade with piezo-based frequency and amplitude control
- Set ultrasonic frequency and amplitude based on fibre diameter: larger fibres (up to 500µm) may require higher amplitude; smaller fibres need lower amplitude to prevent shattering
- Position semi-automated backstop for blade travel limit
- Verify blade is sharp and undamaged (inspect through camera if possible)

Execute cleave - STOP - safety check before cleaving:
- Safety glasses on? YES
- Hands clear of cleaving zone? YES
- Fibre properly positioned? YES
- Initiate cleave command in software
- Ultrasonic blade will advance to fibre, vibrate, and create cleave (typically completes in <1 second)
- Do NOT manually interfere with cleave process

Cleave quality assessment:
- High-resolution camera inspection of cleaved end face
- Good cleave characteristics: flat, perpendicular end face; minimal chipping or fracture; clean separation
- If cleave is poor quality: adjust cleave parameters (frequency, amplitude, blade position); may need to cleave back further and repeat
- Software captures images for documentation

Post-cleave handling:
- Cleaved fibre end is VERY SHARP - use extreme care when removing cleaved component
- Use tweezers or fibre handling tools only
- Place cleaved scrap immediately in sharps container
- Never allow cleaved fibres to fall on floor or work surface

Cleaving blade maintenance:
- Diamond blade requires periodic replacement based on usage
- Signs blade needs replacement: poor cleave quality despite parameter adjustments, visible damage to blade tip, inconsistent cleave results
- Blade replacement procedure: LOCK OUT EQUIPMENT before accessing blade; use nitrile gloves when handling blade; follow manufacturer procedure for safe blade removal and installation; dispose of used blade in sharps container (extremely sharp); test new blade on scrap fibre before critical cleaves

SECTION 7 - EQUIPMENT SHUTDOWN AND POST-OPERATION PROCEDURES:

Prepare for shutdown:
- Complete any in-progress operations
- Remove all fibres from holders
- Collect all cleaved scrap and dispose in sharps container
- Remove any fibre holders or fixtures that are not permanent

Software shutdown sequence:
- Save any custom programs or process data
- Backup critical data if required
- Close processing software following proper exit procedure
- Do NOT force-quit software - may cause data loss or system errors

Plasma system shutdown:
- System will automatically cool down electrodes using embedded cooling
- Allow cooling cycle to complete (typically 5-10 minutes)
- Do NOT power off during cooling cycle
- System will indicate when safe to power down

Vacuum system shutdown (if used):
- Ensure chamber is fully vented to atmosphere
- Verify pressure gauge shows atmospheric pressure
- Safe to power off vacuum pump
- Leave chamber slightly open to prevent seal damage during storage

Compressed air shutdown:
- Close compressed air supply valve (optional - can be left on if equipment used regularly)
- If closing air supply: allow system to depressurise naturally; verify pressure gauge drops to zero
- Do NOT disconnect pressurised lines

Power down sequence:
- Shut down PC in normal manner
- Switch off CMS main power
- Verify all indicator lights are off
- Do NOT disconnect power cables while system is energised

Post-operation inspection:
- Visual check for any damage or issues that developed during session
- Note any unusual behaviour in equipment logbook
- Check work area for any dropped fibres or glass debris
- Verify all sharps have been disposed of properly

Work area cleanup:
- Clean all work surfaces using damp cloth (captures glass fragments)
- Do NOT use compressed air to clean - will disperse glass particles
- Dispose of cleaning materials in general waste (not sharps unless glass embedded)
- Return all tools and accessories to designated storage
- Ensure fire extinguisher and emergency equipment are accessible
- Leave work area clean and ready for next user

Sign out from equipment logbook:
- Record end time, operations completed, component count, any issues
- Note any maintenance needs or concerns
- If any problems occurred: complete incident report if safety-related; tag equipment if not safe to use; inform supervisor immediately of serious issues

PPE removal and hand washing:
- Remove and dispose of nitrile gloves if worn
- Remove safety glasses and store properly
- Remove laboratory coat
- Wash hands thoroughly after handling fibres, electrodes, or chemicals
- Inspect hands for any glass fragments (use magnification if needed)

List emergency shutdown procedures

USE EMERGENCY STOP IN ANY OF THESE SITUATIONS:
- Plasma operation appears abnormal (unusual colour, shape, sound, or behaviour)
- Smoke, fire, or burning smell detected
- Electrical sparking, arcing, or unusual sounds
- Compressed air leak or sudden pressure loss
- Vacuum chamber failure or unusual sounds from vacuum system
- Fibre breakage during processing causing unsafe condition
- Software crash or unresponsive controls
- Personal injury occurring

- Equipment damage visible or suspected
- Any situation where continued operation is unsafe

EMERGENCY SHUTDOWN PROCEDURE:
1. IMMEDIATELY PRESS EMERGENCY STOP BUTTON (large red button on equipment front panel). Pressing will immediately shut down plasma generation, all motion systems, and processing functions. NOTE: the emergency stop does NOT remove electrical power - use the main isolator for electrical emergencies.
2. If emergency stop button fails or is inaccessible: turn off main power at mains isolator switch; close compressed air supply at emergency shut-off valve; evacuate area if situation is worsening.
3. Assess the situation: fire - follow fire emergency procedures; electrical issue - do not approach equipment, call electrician; compressed air failure - evacuate and call facilities/supervisor; personal injury - provide first aid and call emergency services if serious; equipment malfunction - assess damage and determine if area is safe.
4. DO NOT attempt to restart equipment until: the emergency condition has been completely resolved; equipment has been thoroughly inspected by competent person or supervisor; root cause of emergency has been identified and corrected; supervisor has authorised restart in writing; any necessary repairs have been completed and tested; all safety systems verified functional.
5. Complete incident documentation: fill out incident report form immediately while details are fresh (date, time, personnel present, exact circumstances, actions taken; attach photos if equipment damage occurred); submit to supervisor and safety officer; complete RiskWare report if required by university policy. Equipment may need to be locked out pending investigation.
6. Lock out and tag equipment if not safe to use. Tag must state date, reason for lockout, who locked out, and contact details. Only supervisor or authorised maintenance can remove lockout.

RESETTING EMERGENCY STOP (only after emergency fully resolved and authorisation obtained):
1. Verify that emergency condition has been completely addressed
2. Obtain supervisor approval to reset (document in logbook)
3. Rotate emergency stop button clockwise to release (or follow equipment-specific reset procedure)
4. System will require re-initialisation
5. Perform complete pre-operation safety checks before resuming any work
6. Test emergency stop button again to verify it functions correctly
7. Proceed with caution and monitor equipment closely for any recurring issues

List Emergency procedures for how to deal with fires, spills or exposure to hazardous substances

FIRE EMERGENCY:
1. ACTIVATE EMERGENCY STOP to shut down all CMS systems
2. CLOSE COMPRESSED AIR SUPPLY immediately at emergency shut-off valve
3. If fire is SMALL (smaller than a wastebasket) and CONTAINED: use appropriate fire extinguisher (CO2 or dry powder for electrical fires - DO NOT use water on electrical equipment); aim at base of fire, sweep side to side; ensure you have clear escape route behind you; if fire does not extinguish immediately or grows: evacuate
4. If fire is LARGE, SPREADING, or involves compressed gas: evacuate area immediately; close door behind you (do not lock); activate building fire alarm (break glass at alarm point); call 000 (Emergency Services) from safe location and provide location, type of fire, any hazardous materials involved; evacuate to designated assembly point; do not re-enter for any reason
5. If clothing is on fire: STOP, DROP, and ROLL to smother flames; use fire blanket or safety shower if available; once flames out, cool burned area with water; seek immediate medical attention
6. After fire is extinguished: do not re-enter area until declared safe by emergency services or supervisor; equipment must be thoroughly inspected before any restart attempt; complete incident report with detailed description of fire cause and damage; review fire safety procedures and identify any improvements needed

THERMAL BURN INJURY:
1. Immediately move away from heat source
2. Cool affected area under running cold water for at least 20 minutes (cool tap water, not ice; start cooling as quickly as possible; continue cooling even if pain subsides; remove jewellery or constricting items before swelling occurs)
3. Do NOT: apply ice directly to burn; apply butter, oil, ointments, or "home remedies"; break any blisters that form; touch burn with dirty hands or materials
4. After cooling, cover burn with sterile non-stick dressing from first aid kit (clean plastic wrap as alternative); do NOT use fluffy materials (cotton wool) that may stick

5. Seek immediate medical attention for: burns larger than a 20-cent coin (5cm diameter); burns to face, hands, feet, genitals, or major joints; burns that appear deep (white, waxy, charred, or painless); burns causing severe pain or extensive blistering; burns from electrical source; burns from chemical contact; any uncertainty about burn severity. Call 000 for severe burns.
6. For minor burns (small, superficial, not on sensitive areas): continue cooling for 20 minutes; apply sterile dressing; may use over-the-counter pain relief if needed; monitor for signs of infection (increased pain, redness, swelling, pus); seek medical review if any concerns
7. Complete incident documentation: record details in equipment logbook; fill out incident report form; notify supervisor immediately; complete RiskWare report; investigate how burn occurred to prevent recurrence

ELECTRIC SHOCK:
1. DO NOT touch the person if they are still in contact with electrical source - you may also be shocked
2. Break the circuit: switch off power at mains isolator, or use non-conductive material (dry wood, plastic) to move person away from source - only if safe to do so
3. Call 000 immediately if person is unconscious or not breathing, showing signs of serious shock (pale, clammy, rapid pulse), or burned from electrical contact
4. If person is unconscious: check for breathing; if trained in CPR and person not breathing, commence CPR; continue until emergency services arrive or person recovers
5. If person is conscious but shocked: have them lie down and remain still; keep warm with blanket if available; treat any burns (see thermal burn procedure); seek medical attention even if person feels "fine" - electrical shock can cause internal injuries
6. LOCK OUT AND TAG EQUIPMENT: equipment that delivered shock must be locked out immediately; attach tag stating "Electrical hazard - Do not use"; only qualified electrician can inspect and clear equipment for use
7. Complete incident documentation: document exact circumstances of shock; identify electrical fault that caused shock; ensure equipment is repaired before any future use; review electrical safety procedures

GLASS INJURY (CUTS OR EMBEDDED FRAGMENTS):
1. For minor cuts: rinse wound gently with clean water; apply pressure with clean cloth if bleeding; once bleeding stopped, apply sterile adhesive dressing; monitor for signs of infection
2. For EMBEDDED glass fragments: DO NOT attempt to remove large or deep embedded glass; cover area with sterile dressing; seek medical attention for professional removal; DO NOT apply pressure over embedded glass
3. For deep cuts or severe bleeding: apply direct pressure with clean cloth; elevate injured area above heart level if possible; do NOT remove cloth if blood soaks through - add more layers on top; call 000 if bleeding is severe or does not stop within 5-10 minutes; keep person calm and lying down; monitor for signs of shock (pale, clammy, weak pulse)
4. For EYE injuries involving glass: DO NOT rub eye; DO NOT attempt to remove any object from eye; DO NOT apply pressure to eye; cover eye gently with sterile dressing (no pressure); seek IMMEDIATE medical attention at emergency department; call 000 if object embedded in eye or severe pain; cover both eyes to prevent movement (injured eye will track with healthy eye)
5. After treatment: all glass injuries, even minor, must be reported to supervisor; complete incident report; investigate how glass injury occurred; review handling procedures to prevent recurrence; ensure sharps disposal procedures are being followed
6. First aid supplies for glass injuries: sterile dressings in various sizes; adhesive bandages; splinter removal tweezers (for tiny superficial fragments only); eye wash and eye pads; clean water for rinsing wounds

COMPRESSED AIR SYSTEM FAILURE / AIR BLAST:
1. ACTIVATE EMERGENCY STOP
2. CLOSE COMPRESSED AIR SUPPLY at emergency shut-off valve
3. EVACUATE AREA if loud hissing, visible high-pressure air leaks, or flying debris
4. DO NOT approach failed air lines or fittings - high-pressure air can cause serious injury
5. If injury from air blast: move to safe area away from air stream; seek IMMEDIATE medical attention for suspected air embolism (signs: chest pain, difficulty breathing, confusion, loss of consciousness) - call 000, air embolism is life-threatening; do NOT allow casualty to move excessively - may worsen embolism; treat any projectile injuries (embedded objects, cuts, bruises)
6. Never use compressed air to clean clothing or body, direct at another person, or blow dust or debris (creates airborne hazards)
7. After system failure: LOCK OUT AND TAG equipment; contact facilities/maintenance for pressure system inspection; only qualified technician can repair and re-certify compressed air system; complete incident report documenting failure mode

VACUUM SYSTEM FAILURE:
1. ACTIVATE EMERGENCY STOP

2. If catastrophic failure (implosion, explosion, or violent air inrush): evacuate area immediately; call 000 if injuries present; do not re-enter until area declared safe by supervisor or emergency services
3. If controlled venting or slow leak: allow system to vent to atmosphere naturally; monitor pressure gauge; once at atmospheric pressure, open chamber slowly; inspect for damage before any further use
4. Injuries from vacuum failure: flying glass or debris - treat as cuts/embedded fragments (see glass injury procedure); noise trauma - seek medical review if hearing affected; crush injuries - seek immediate medical attention
5. After vacuum system failure: LOCK OUT AND TAG equipment; only qualified technician can inspect vacuum chamber and seals; pressure testing may be required before return to service; document failure mode in incident report

CHEMICAL EXPOSURE (ELECTRODE MATERIALS OR CLEANING CHEMICALS):
1. Skin contact: immediately remove contaminated clothing; rinse affected area with copious running water for at least 15 minutes; do NOT use neutralising agents unless specifically directed by SDS; if irritation persists, seek medical attention; bring SDS with you to medical facility
2. Eye contact: immediately flush eye with water or eyewash for at least 15 minutes; hold eyelids open to ensure thorough rinsing; remove contact lenses if present and easy to remove; seek immediate medical attention after flushing; bring SDS to medical facility
3. Inhalation: move to fresh air immediately; loosen tight clothing; if breathing difficulty, seek immediate medical attention; call 000 if severe respiratory distress; bring SDS to medical facility
4. Ingestion (unlikely but possible): do NOT induce vomiting unless directed by Poisons Information; rinse mouth with water; call Poisons Information Centre 13 11 26 and follow their advice; seek medical attention; bring chemical container or SDS
5. After chemical exposure: complete incident report; review SDS and handling procedures; identify how exposure occurred and implement prevention

SOFTWARE / CONTROL SYSTEM FAILURE:
1. Attempt emergency stop via software interface (if responsive)
2. If software unresponsive: press physical emergency stop button; if both fail, turn off power at mains isolator
3. Record any error messages or system state: take photo of screen if possible and safe; note exact sequence of events leading to failure; do NOT attempt to troubleshoot during active emergency
4. After system is stopped: DO NOT attempt to restart; LOCK OUT AND TAG equipment; contact IT support or manufacturer technical support; only qualified technician can diagnose and repair software/control issues
5. Data preservation: if safe to do so, attempt to save any critical process data before complete shutdown; system logs may help diagnose software failure
6. Complete incident report documenting software failure and any equipment impact

EMERGENCY CONTACTS:
- Emergency Services (Police, Fire, Ambulance): 000 - call for fires, serious injuries, life-threatening situations
- Poisons Information Centre: 13 11 26 - 24/7 advice for chemical exposures and ingestions
- University Security (after hours): [Insert number] - for emergencies outside business hours; can contact emergency services and key personnel
- Supervisor: [Name and number] - first point of contact for equipment issues; can authorise equipment restart after emergencies
- Safety Officer: [Name and number] - for incident reporting and safety advice; for hazard assessments and risk management
- First Aid Officers: [Names and contact details / Notice board location] - trained in emergency first aid
- Facilities Management: [Insert number] - for electrical, plumbing, HVAC emergencies; for compressed air system issues
- IT Support: [Insert number] - for software and computer system issues; can assist with data recovery
- 3SAE Technical Support: +1 615-778-8812, info@3sae.com - manufacturer support for equipment issues (available during US business hours; may have time zone delay)

List Clean up and waste disposal requirements

AFTER EACH USE - PROCESSING CHAMBER AND FIBRE HOLDERS:
- Remove all fibre remnants from holders using tweezers
- Inspect holders for glass debris or contamination
- Wipe holders with lint-free cloth if needed

- Do NOT use solvents on fibre holders unless specified by manufacturer
- Return holders to designated storage

ELECTRODE CLEANING (periodic - follow manufacturer schedule):
- Performed when electrodes show visible contamination, or per manufacturer interval
- Safety requirements: equipment must be powered off and cool; wear nitrile gloves; perform in well-ventilated area
- Procedure: remove electrode assembly following manufacturer instructions; use provided electrode cleaning discs; clean electrode surfaces gently to remove oxidation or deposits; inspect for wear (replace if worn beyond manufacturer limits); reinstall electrodes ensuring proper positioning
- Disposal: used cleaning discs in general waste; worn electrodes in sharps container or per manufacturer instructions

CAMERA LENSES AND OPTICS:
- Inspect telecentric lenses for dust or contamination
- Clean ONLY with proper lens tissue and lens cleaner
- Never use paper towel, cloth, or harsh chemicals (will scratch lenses)
- Clean gently in circular motion from centre outward
- If optics are heavily contaminated: contact supervisor (may need professional cleaning)

WORK AREA AND BENCHTOP:
- Remove all materials, tools, and personal items
- Wipe down work surface with damp cloth to capture glass fragments
- Do NOT use compressed air to clean benchtop - disperses glass particles into air and onto equipment
- Check for dropped fibres on floor or adjacent surfaces
- Leave work area clean and organised for next user

GLASS WASTE (FIBRE SCRAPS, CLEAVED ENDS, BROKEN COMPONENTS):
- All glass waste goes in sharps container - NEVER in general waste (includes cleaved fibre ends, failed splices or tapers, broken fibres, any glass fragments)
- Sharps container must be a puncture-proof rigid container, clearly labelled "Glass Sharps", positioned within easy reach of work area, and never filled beyond 3/4 full
- When full: contact waste management for sharps container replacement

ELECTRODE WASTE:
- Worn electrodes: sharps container or follow manufacturer disposal instructions
- May contain metal materials requiring specific disposal; contact waste management if uncertain

CHEMICAL WASTE (CLEANING AGENTS, ISOPROPANOL, ETC.):
- Small quantities of isopropanol used for fibre cleaning can evaporate or be disposed via solvent waste
- Larger quantities or other chemicals: use university chemical waste system
- Never pour chemicals down sink unless specifically approved
- Label all waste containers clearly; consult SDS for disposal requirements

GENERAL WASTE AND RECYCLING:
- General waste: non-contaminated packaging materials; paper towels (that haven't contacted glass); disposable gloves (if not contaminated with chemicals); general laboratory waste
- Recycling: fibre spools and packaging may be recyclable; check with waste management for specific requirements; remove all labels and contamination before recycling

PERIODIC MAINTENANCE CLEANING:
- Weekly: thorough wipe-down of equipment exterior; vacuum or damp-wipe floor area around equipment; check that all waste containers have adequate capacity; inspect work area organisation and storage
- Monthly: detailed cleaning of all accessible surfaces; inspection of air filters (if present) and cleaning if needed; check cable routing and organisation; review housekeeping procedures with all users
- Annually (or per manufacturer schedule): professional equipment cleaning and maintenance; inspection and cleaning of internal components by qualified technician; replacement of any worn or deteriorated parts; calibration and alignment verification

MAINTENANCE LOG:
- Document all cleaning and maintenance activities in equipment logbook
- Record date, type of cleaning/maintenance, person performing, any issues noted
- Track electrode replacement and usage hours
- Schedule and track periodic maintenance tasks

List references used in the development of this SWP, e.g. codes of practice

AS/NZS 60825.1:2014 - Safety of laser products

AS/NZS 3000:2018 - Electrical installations (Wiring Rules)

AS 2243 Series - Safety in laboratories

AS 4343:2014 - Pressure equipment - Hazard levels

Work Health and Safety Act 2011

Work Health and Safety Regulation 2017

3SAE CMS Product Information Sheet (https://3sae.com/wp-content/uploads/2024/01/CMS.pdf)

3SAE CMS Operator's Manual and User Documentation

3SAE Combiner Manufacturing System technical specifications

Manufacturer training materials (3SAE Technologies Inc.)

Risk Assessment RA-A28-SAIL-218G-3sae-cms

University WHS policies and procedures

Material Safety Data Sheets for all chemicals used with equipment

Code of Practice: Managing electrical risks in the workplace

List competency required – qualifications, certificates, licensing, training - e.g. course or instruction:

MANDATORY TRAINING (must be completed and documented before authorisation; records maintained by supervisor):

1. Manufacturer training course - 3SAE CMS multi-day on-site installation and operational training (TRN-01-0012):
- Key learning outcomes: equipment overview and capabilities; safety systems and emergency procedures; control software operation (LabVIEW GUI); fusion splicing techniques and parameters; fibre tapering methods (bidirectional, single-direction, table-based); precision cleaving operation; electrode maintenance and replacement; troubleshooting and diagnostics; best practices for different fibre types and diameters
- This training is ESSENTIAL - no substitutes; typically 2-3 days depending on applications; certificate of completion must be obtained

2. Laboratory safety induction:
- General laboratory safety requirements; emergency procedures and assembly points; location and use of safety equipment (fire extinguishers, eyewash, first aid); chemical safety and SDS interpretation; incident reporting procedures; personal protective equipment requirements

3. Fibre optic handling and safety:
- Optical fibre types and characteristics; safe handling techniques for glass fibres; hazards of glass fragments and cleaved ends; proper use of fibre handling tools; sharps disposal procedures; first aid for glass injuries; eye protection requirements

4. Electrical safety awareness:
- Basic electrical hazards; lockout/tagout procedures; RCD function and testing; emergency power isolation; when to contact qualified electrician
- Do NOT attempt electrical repairs without qualifications

5. High-temperature process safety:
- Thermal hazards from plasma operation; safe distances and exclusion zones; cooling time requirements; recognition of hot surfaces; thermal burn first aid; heat-resistant glove use and limitations

6. Compressed air and vacuum systems safety:
- Hazards of high-pressure systems; safe connection and disconnection procedures; pressure monitoring and

relief; vacuum chamber operation; emergency shutdown procedures; compressed air safety (never direct at body)

THEORY ASSESSMENT (written test or oral examination):
- Safety-critical knowledge (must achieve 100%): emergency stop procedure and location; emergency shutdown for different emergency types; thermal burn first aid procedures; glass injury prevention and first aid; electrical safety and when to evacuate; compressed air system hazards; when operation must stop (red flags); PPE requirements for different tasks
- Equipment knowledge (minimum 80% pass mark): CMS capabilities and specifications; fusion splicing principles and parameters; tapering methods and applications; cleaving operation and quality assessment; software interface and control functions; electrode function and maintenance; cooling system purpose; vision system operation
- Procedure knowledge (minimum 80% pass mark): pre-operation safety checks; fibre preparation and loading; splice parameter selection; taper program configuration; cleave positioning and execution; shutdown procedures; cleaning and waste disposal; documentation requirements
- Failed assessment: review training materials, additional instruction, retest

PRACTICAL ASSESSMENT (supervised demonstration of competency):
- Pre-operation procedures: complete all safety checks correctly; identify and test emergency stop; verify safety equipment presence; set up work area appropriately; don proper PPE
- Basic operation: power up system correctly; inspect and install electrodes; load fibres into holders safely; achieve proper fibre alignment; execute a simple fusion splice; assess splice quality; properly shut down system
- Advanced operation (as applicable to user's role): configure and execute taper program; perform precision cleave; use scanning functions; operate vacuum system (if required); create custom splice/taper parameters
- Emergency response: demonstrate emergency stop activation; describe appropriate response to different emergency scenarios; locate and identify use of emergency equipment; demonstrate understanding of when to evacuate vs respond
- Housekeeping: proper cleanup procedures; correct waste disposal; appropriate documentation in logbook
- Assessor must observe ALL practical elements. Any safety-critical errors result in immediate FAIL - retraining and reassessment required. Minor non-safety errors: corrective instruction provided, reassessment of that element only. All elements must be demonstrated competently before authorisation granted.

REFRESHER TRAINING:
- Annual refresher required for all authorised users, covering safety procedure updates, any equipment modifications or new capabilities, review of common errors or incidents, new techniques or best practices, and changes to Australian Standards or regulations

RETRAINING REQUIRED WHEN:
- Any safety incident involving this equipment (immediate retraining); safety procedures are updated or changed; equipment is significantly modified or upgraded; unsafe practices are observed (remedial training); extended period of non-use (>6 months requires supervised refresher); new applications or techniques are implemented; user requests refresher training

SUPERVISION REQUIREMENTS (based on experience level):
- Novice users (0-10 operations): direct supervision required at all times; supervisor must be experienced CMS user, present in same room and actively observing; each operation reviewed with supervisor before and after
- Intermediate users (11-30 operations): experienced user must be present in laboratory; supervisor available for consultation; can perform routine operations independently with oversight; new or complex operations require direct supervision
- Experienced users (31+ operations, demonstrated consistent competency): may operate independently; should consult with colleagues for unusual situations; responsible for mentoring and supervising novice users; maintain competency through regular use (minimum monthly)

MEDICAL MONITORING:
- Not routinely required for CMS operation; eye examinations recommended for frequent users (discuss with OH&S); any health concerns affecting ability to operate safely must be reported to supervisor; vision requirements: must be able to view monitor clearly and distinguish alignment on camera views

RECORD KEEPING:
- Training records: manufacturer training certificate (keep copy); laboratory safety induction completion; all supplementary training courses; refresher training attendance; maintained by supervisor, copies in personnel files
- Competency assessments: theory assessment results; practical assessment checklist (signed by assessor); date competency achieved; any remedial training and reassessment; maintained by supervisor
- Authorised users list: current list of all authorised users with date authorised and authorisation level; displayed prominently near equipment; updated when users added or removed; reviewed annually, remove inactive users

- Individual operation logs: each user's operation count tracked in logbook to determine supervision requirements and identify when refresher training may be beneficial
- Incident and near-miss records: any safety incidents involving specific users may trigger retraining requirements; pattern analysis for systemic issues; maintained by safety officer

COMPETENCY RENEWAL:
- Annual competency review by supervisor considering frequency of equipment use, any incidents or near-misses, refresher training completion, observed work practices, and changes in procedures or equipment
- Supervisor may require reassessment if concerns identified
- Users who have not operated equipment in >12 months: full reassessment required

ASSESSOR REQUIREMENTS - to be authorised as an assessor, staff must:
- Have completed 3SAE manufacturer training course; have minimum 100 successful operations on CMS (extensive experience); demonstrate expert-level knowledge of all CMS functions and safety systems; have no significant safety incidents on record; understand adult learning principles and assessment techniques; be approved by laboratory manager AND safety officer; maintain current competency through regular equipment use

ASSESSMENT PROCESS:
1. Trainee completes all mandatory training modules and reviews this SWP and the associated Risk Assessment thoroughly
2. Assessor conducts theory assessment (safety-critical questions must achieve 100%; general knowledge minimum 80%; if failed: review materials, additional instruction, retest)
3. Assessor supervises practical demonstration using the practical assessment checklist (any safety-critical errors result in immediate fail; corrective instruction provided for minor errors)
4. Assessor verifies competency in all required areas, confirms trainee understands limitations and when to seek help, and verifies trainee can respond appropriately to emergencies
5. If competent: assessor signs trainee off on sign-off sheet; date of authorisation recorded; supervision requirements specified based on experience level; trainee added to authorised users list
6. If not yet competent: specific deficiencies identified and communicated; additional training and supervised practice required; reassessment scheduled once trainee ready (may be partial reassessment of only deficient areas)
7. Once signed off: name added to authorised users list displayed near equipment; laboratory manager notified

AUTHORISED USERS LIST MAINTENANCE:
- Maintained by laboratory manager; displayed prominently near CMS equipment
- Updated when new users are authorised, users move to different supervision levels, users become inactive, or users require retraining (temporarily suspend if safety issue)
- Reviewed annually as part of SWP review
- Records name, date authorised, authorisation level (Novice / Intermediate / Experienced), supervision required, authorised by, and notes

Staff approved to assess competence for this SWP

[Name 1], [Name 2]

SWP Sign off sheet	
SWP name and version:	**Operation of 3SAE Combiner Manufacturing System (CMS) for Fibre Optic Glass Processing (Version 1.0)**

In signing this section the assessor agrees that the following persons are competent in following this SWP.

Name	Signature	Date Competent	Name of Assessor/Authoriser	Assessor/Authoriser signature

Risk Matrix

			Potential Consequences				
			Class 3	Class 2	Class 2	Class 1b/1c	Class 1a
			Minor injuries or physical discomfort. Short-term psychological impact (isolated or one-off event).	Injury or illness requiring medical treatment and/or short-term impairment (less than 2 weeks). Psychological impact requiring support.	Injury or illness requiring hospital admission and/or temporary impairment (less than 6 months). Psychological impact requiring medical treatment.	Injury or illness (physical or psychological) resulting in long-term or permanent impairment (more than 6 months). Injury or illness resulting in temporary impairment to multiple people.	One or more fatalities. Injury or illness resulting in long-term or permanent impairment to multiple people.
			Insignificant	**Minor**	**Moderate**	**Major**	**Severe**
Likelihood	Expected to occur regularly under normal circumstances	**Almost Certain**	**Medium**	**High**	**Very High**	**Very High**	**Very High**
	Expected to occur at some time	**Likely**	**Low**	**Medium**	**High**	**Very High**	**Very High**
	May occur at some time	**Possible**	**Low**	**Medium**	**Medium**	**High**	**High**
	Not likely to occur in normal circumstances	**Unlikely**	**Low**	**Low**	**Medium**	**Medium**	**High**
	Could happen, but probably never will	**Rare**	**Low**	**Low**	**Low**	**Medium**	**Medium**