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Pulling/Welding Procedure (LASTI, September 2009)

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1 Introduction

1.1 Purpose and Scope

This document describes the pulling welding procedure as observed by Mark Barton at LASTI during the monolithic test hangs of August 2009. It is written in the style of an instruction manual for ease of recycling the text into future procedure documents but except where noted is actually historical.

1.2 References

1.3 Version history

8/18/2009: First pre-v1 draft.

8/20/2009: Second pre-v1 draft incorporating Liam's input.

9/11/2009: Third pre-v1 draft including additional observations September 8-11. Released as v1

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

2 Fibre preparation

This version of the procedure is the quick one used at LASTI in September 2009 where fuse-ends are only glued on after pulling. It saves time for initial debugging of the pulling process (laser power and alignment etc) where visible defects are common and most fibres are not proof-tested or profiled. However for production fibres the fuse-ends should be put on first.

2.1 Pulling a fibre

Step	What	Where	Time	People	Tools
1	Prepare to power up laser: clear area of non-essential personnel, lock door, switch on cooler, ensure all valves are open, turn main wall switch on, check laser warning sign is illuminated.		1 min	1	
2	Install non-fuse-end clamps on pulling machine.				
3	Repeat the next few steps for as many fibres as are required (approximately 6 for welding, 3 for testing and 1 spare).				
4	Measure a 10 cm length of 3 mm stock, scribe with a diamond tipped tool, and snap off.		1 min	1	
5	Clean stock with first an acetone-soaked wipe, then a methanol-soaked wipe.		1 min	1	
6	Install stock in groove of lower clamp and tighten retaining screw gently.		1 min	1	
7	Check that upper clamp is well-aligned with stock, adjust horizontal position if necessary, and tighten retaining screw gently. Wipe with methanol again.		1 min	1	
8	Arm laser: check motorized shutter is closed. Close all doors to laser enclosure except the one convenient to the rear end of the laser. While holding the red interlock defeat button, turn the laser key to the ON position and close the last door.				
9	Open the LabView pulling program on the computer and select the polish-down data set. Press the Labview run button, then click on the software Begin button. The software will now wait for the shutter to be		1 min	1	

Step	What	Where	Time	People	Tools
	opened				
10	From the UC2000 controller, set the power to full and set the laser to lase.		1 min		
11	Open the motorized shutter and the polish program will begin to run. Stop after the display reads approx 40 mm. Close shutter, click on All Stop to end program.		20 min		
12	Select and run the polish-up data set. Stop after the display reads approx 40 mm. Close shutter, click on all stop to end program.		20 min		
13	Run LabView program ????.vi. Use it to move the lower arm down by 10 mm (i.e., to the desired start point for pulling). [This needs to be incorporated into a future version of the pulling program.]				
14	Run the pulling program again.				
15	Select and run the desired pulling data set.		2 min		
16	Close motorized shutter and set laser to off at the UC2000 controller.		1 min		
17	Wait 5 min for fibre to cool.		5 min		
18	Loosen bottom clamp screw.		1 min		
19	Click Motor Advance screen button in pulling program to raise the upper carriage and lift the fibre clear of the lower clamp.		1 min		
20	Hold the upper end of the stock with a gloved hand as near as possible to the clamp, loosen the clamp screw and remove the fibre. If the section of stock at the bottom is longer (and thus easier to hold away from the neck, as is the case with the current settings), grasp it with a second gloved hand and turn the fibre upside down. Be <i>extremely</i> careful not to touch the thin section or either of the necks.		1 min		
21	Click on reset button in software.				
22	If the fibre is free of obvious defects, glue either fuse-ends or cardboard to the ends depending on whether it is to be proof tested before use (non-destructively), or strength tested (destructively).				
23	Test the fibre according to Section 5.1 or 5.2.				

3 Welding

3.1 Welding setup

Step	What	Where	Time	People	Tools
1	Place breadboard on jacks at convenient position on floor.		10 min	2	breadboard, jacks
2	Level breadboard using jacks and, if necessary, shims.		10 min		bubble level, shims, wrench (for jacks)
3	Setup turntable and riser on top of base breadboard.		10 min		
4	Put LSAT on riser and recheck level.		10 min		bubble level
5	Put main chain half of lower structure frame into LSAT and secure with clamps, spacers and shims. [Improvised items were used, but RAL is working on a custom set.]				assorted clamps and shims
6	Setup TM jack. [This was done by propping it up on improvised spacers, but there needs to be a custom-built spacer that is exactly the right height and can be bolted to the turntable with a small horizontal adjustment range to allow for precise centering. RAL is working on it.]				jack, approx 12" of spacers for under jack
7	Put dummy masses into lower structure.				dummy PM, TM
8	Set PM at correct height using stops, and align				
9	Raise TM on jack until it clears the stops.				
10	Slide the jack on turntable to position the TM horizontally relative to the structure. The mass should be centered laterally and the face on the reaction chain side should be flush with the outside of the lower structure. Secure the jack in place with shims and clamps.				shims, clamps
11	Put disk insert plates into slots in sides of dummy PM but displaced 1-2" to one end of the slot, so that a bubble level can be placed across the face and perch on the protruding ends. Clock the mass to put the two plates at the same height.				disk insert plates
12	Set the vertical separation of the masses to the appropriate value for welding using the jack under the TM.				ruler
13	Repeat the clocking procedure for the TM.				

Step	What	Where	Time	People	Tools
14	Attach the shelf brackets and shelves to the LSAT but leave them rotated out of the way to allow easy access to the flats on the masses.				
15	Attach the weld tooling scaffolding with clamps. [The welding scaffolding is optimized for the Bosch dummy LSAT at Glasgow and the interface could use some redesign. This will probably involve a few holes in the real LSAT.]				

3.2 Welding

Step	What	Where	Time	People	Tools
1	Turn on computer, run LabView program and open welding VM.				
2	Repeat steps down to 35 for each fibre.				
3	Set the appropriate distance between the lower clamp blocks on the fibre cutter and remove the upper clamp blocks.				
4	Lay the plastic tabs on the back of the fibre cutter to the outside.				
5	Make sure the tweezers on the bow are fully retracted and open.				
6	Install the bow on the fibre cutter and rotate the plastic tabs behind it to lock it in place.				
7	Select a fibre from storage and lay it in the cutter with equal amounts of neck inside the clamp blocks at each end. Be very careful no fingers or anything else touch the fibre.				
8	Install the upper clamp blocks and screw them down firmly onto the necks of the fibre.				
9	Using a small file or diamond scribe, score each end of the stock at a point immediately to the outside of the clamp. Snap off the stock and fuse-end and, if necessary, clean up the end of the section of stock in the clamp with the file.				file/scribe
10	Using the translation stage, bring in each pair of tweezers with the jaws still open until the groove in the tips is aligned with the neck of the fibre as near as possible to (or even touching) the inside of the clamp and then				

Step	What	Where	Time	People	Tools
11	tighten the jaws to grip the fibre. Remove the top clamp pieces.				
12	Retract the tweezers so as to move the fibre clear of the lower clamp pieces.				
13	Flip the plastic tabs on the cutter and remove the bow with the fibre.				
14	Bring the bow with the fibre to the structure and attach it to the welding scaffolding. Be very careful not to let fingers or anything else touch the fibre.				
15	Adjust the movable stages holding the tweezers vertically so that the ends of the fibres are inset about 1 mm each from the tips of the ears. (This will cause the fibre to bow slightly in the centre.)				
16	Adjust the movable stages in the direction parallel to the flat on the optic so that the fibre ends are directly opposite the tips of the ears as viewed straight on from the flat.				
17	Adjust the movable stages in the direction normal to the flat until the fibre ends are directly opposite the tips of the ears as viewed from along the flat.				
18	Move the adjustable stages vertically until the gaps between the fibres and ears close up. If necessary tweak the other two directions until the alignment is perfect.				
19	Position the V-shaped welding mirror behind the fibre.				
20	Attach the Lexan safety shield to the side of the LSAT.				
21	Repeat steps down to 32 for both ends of the fibre.				
22	Swing the shelf into position and tighten.				
23	Attach the birdcage to the shelf with the business end toward the ear. (Do not move the birdcage with the articulated arm attached - there is a risk of misaligning the arm if the birdcage is dropped or moved in a way that the arm can't follow.)				
24	From the computer, set the galvo mirrors to the middle of their range.				
25	Attach the articulated arm to the birdcage.				

Step	What	Where	Time	People	Tools
26	Turn the laser on, set the power to zero, and open the shutter to let the pilot beam through to the birdcage.				
27	Adjust the position of the birdcage until the pilot beam is normal to the flat and focused on the welding zone.				
28	Dim the room lights for better visibility of the pilot beam, point the beam at a representative selection of different places as if welding, and position baffle plates to catch all stray reflections.				
29	Don welding goggles.				
30	Set laser to lase, and using laser power and galvo controls, zap the welding zone from three angles. While heating the vertical stage should be used to push the stock end into the ear to ensure proper fusing of the two pieces.				
31	Set the laser power to zero, close the shutter.				
32	Disconnect the articulated arm, move it to a safe position out of the way and then remove the birdcage.				
33	When both welds have been done, remove the Lexan shield on the side of the LSAT.				
34	Open the tweezers at each end of the bow.				
35	Carefully unbolt and withdraw the bow.				
36	When all four fibres have been welded, continue with stress relieving as below.				
37	Retract each lower earthquake stop screw on the lower mass $\frac{1}{4}$ turn to lower the mass slightly and put slight tension on the fibres.				
38	Repeat steps down to 41 for each of the top necks.				
39	Set up the birdcage, articulated arm and baffles as previously.				
40	Stress relieve from three angles.				
41	Move the beam down towards the neck and flame polish from three sides where the tweezers contacted.				
42	When all top welds have been done, lower the bottom mass another $\frac{1}{4}$ turn of the screws.				

Step	What	Where	Time	People	Tools
43	Repeat steps down to 46 for each of the bottom necks.				
44	Set up the birdcage, articulated arm and baffles as previously.				
45	Stress relieve from three angles.				
46	Move the beam up towards the neck and flame polish from three sides where the tweezers contacted.				
47	Turn off laser and remove all welding apparatus.				
48	Raise jack to take the load off the fibres then screw out the stops to allow for extension of the fibres. The fibres will extend ~6.5 mm when fully loaded.				
49	Lower the mass very slowly on the jack until the full weight is suspended. Bring stops back to approx 1 mm from the mass.				

4 Setup procedures

4.1 Adjusting focus of welding output telescope

Step	What	Where	Time	People	Tools
1	??			1	

5 Testing procedures

5.1 Proof testing a fibre

The proof tester requires fuse-ends on the fibre. Ideally these should be put on before pulling but at LASTI in August 2009, they were put on afterwards for the fibres to be proofed and used. Throughout this procedure, wear gloves and avoid letting anything touch the fibre in the thin section or near either neck.

Step	What	Where	Time	People	Tools
1	Fuse ends should be glued using low outgas epoxy (if available), and left to cure for the appropriate length of time.		??	1	Epoxy?
2	Make sure proof mass is on hydraulic lifter and at a suitable height, so that when the top fuse end is held beside the connection at the top of the cabinet, the bottom fuse ends dangles a tiny bit (1/8") below the		1 min	1	

Step	What	Where	Time	People	Tools
	connection on the mass.				
3	Put the top fuse end into the top connection and insert the cotter pin.		1 min	1	
4	Put the bottom fuse end into the bottom connection and insert the cotter pin.		1 min	1	
5	Close the cabinet door.		1 min	1	
6	Open the valve on the hydraulic lifter to lower the mass until it suspends (or the fibre breaks). Leave suspended for at least 1 minute.		2 min		
7	If the fibre survives, pump the handle on the hydraulic lifter to raise the mass until the fibre is slack.		1 min		
8	Open the cabinet.		1 min		
9	Remove the bottom cotter pin.		1 min		
10	Hold the fibre by the top fuse-end, remove the top cotter pin and remove the fibre.		1 min		

5.2 Strength testing a fibre

Until such time as the LASTI strength tester is provided with fixtures to accommodate fuse ends, strength testing can only be done with bare-ended fibres. Throughout this procedure, wear gloves and avoid letting anything touch the fibre in the thin section or near either neck.

Step	What	Where	Time	People	Tools
1	Cut four pieces of cardboard approximately 1½"x1½".		1 min	1	cardboard, scissors
2	Crush cardboard and fold along the middle then coat surfaces with superglue. Place one piece on either side of the stock material and press tightly, hold for 30s to 1 minute. Repeat for opposite end, making sure to put the second piece of cardboard coplanar with the first.		2 min	1	SuperGlue
3	Leave SuperGlue to dry for 10 minutes or until the smell subsides, whichever is longer.		10 min		
4	Push up the grippers in the top jaw of the strength tester and insert one cardboard sandwich. Check that the protruding fibre is pointed straight down and press the grippers back down to grip the cardboard.		1 min		

Step	What	Where	Time	People	Tools
5	Raise or lower the carriage of the strength tester to put the lower jaw level with the bottom cardboard, raise the grippers, insert the cardboard, check alignment and lower the grippers.		1 min		
6	Close the cabinet door.				
7	Press PEAK, then RESET, then PEAK again on the load cell readout (the display should flash).				
8	Set the carriage moving down slowly.		1 min		
9	Wait till fibre breaks and note reading on load cell readout.		3 min		

6 Template

Step	What	Where	Time	People	Tools
10				1	