Mech 457 Design Project
Bollard Design

Final Report

Karl Carlson
Tim Chen
Radoslaw Komenda
Alex Wilson

Date Submitted: April 27, 2007

TABLE OF CONTENTS AND LIST OF FIGURES

1.0 PROJECT SUMMARY……………………………………..……………….…….3

2.0 WORK COMPLETED...……………………………………………………...…4

3.0 FINAL COSTS…………………………………………………….……....5

4.0 RECOMMENDATIONS..…………………………………………………....5

5.0 CONCLUSIONS………………………………………………………….…..7

6.0 APPENDICES……………………………………………………………...8

6.1 Appendix A – Project Expenses……………………………………….…..8

6.2 Appendix B – Cost Estimates for Manufacture……………………….……....9

6.3 Appendix C – References………………………………………….…...…17

6.4 Appendix D – Proposal Report…………………....………………………...D1

6.5 Appendix E – Concept Generation, Analysis, and Scoring Report…………E1

6.6 Appendix F – Technical Analysis Report………………………………...F1

6.7 Appendix G – Bollard Testing……………………………………………....G1

6.8 Appendix H – Technical Drawings…………………………..…………..H1

Project Summary

The purpose of this project was to design a replacement for the existing bollard product used at the University of British Columbia campus. The existing product is expensive, difficult to import from the US, and needlessly complex. In examining the requirements for the replacement, the following criteria were identified:

- Fire trucks must be able to pass the device as quickly as possible without the firemen getting out of the vehicle.
- UBC crews must be able to manually disengage the device in order to bypass it.
- All other vehicles must be prevented from bypassing the device.

After identifying these requirements, plus additional needs, the remainder of the design process was followed to the end result of a working prototype, and engineering drawings necessary to produce a fully working model.

Work Completed

The Bollard Design Team has accomplished much work to the ends of designing and building a collapsible bollard for UBC's Land and Building Services. First, the functional requirements were defined, which were obtained from the client. A proposal report was written (see Appendix D) outlining a plan to carry out the given tasks, as well as to make certain the clients needs were understood. This was followed by concept generation, analysis, and scoring (see Appendix E). In the midst of doing technical drawings for the design, a simpler, better design was thought of and chosen instead. A Technical Analysis Report (see Appendix F) was completed. It contains sizing of all important features of the bollard. A test was performed to determine the force required to disengage the current collapsible bollard used by UBC Land and Building Services, so as to finalize the sizing of the components. This test is documented in Appendix G. The intent was to size the shear pin so that at least the same breaking force is required. Due to the chrome finish of the bumpers of the fire trucks, a large increase in breaking force was not desired.

Technical drawings were completed next (see Appendix H). These include all drawings necessary for manufacture of the design. A prototype was constructed by the Bollard Design Team using the machine shop at UBC. Material was primarily acquired from a metal supermarket in Burnaby, BC. Upon completion, the prototype was tested using the same procedure as the initial test on the current design. The prototype met all expectations. The shear pin broke as planned, and replacement of the pin was extremely fast and easy. Also, it was found that the shoulders in the base component were not needed. However, the load cell meter reading went higher than expected, and so was disconnected to ensure that is was not damaged. Another test was carried out using mechanical advantage through the use of a pulley. The force needed is about twice as much, compared to the lower breaking force of the existing bollard (there are 2 different breaking forces depending on which direction the bollard is hit). This increases vandalism resistance, but will not greatly damage vehicles, and thus is acceptable.

Finals Costs

Expenses incurred during the project are listed in Appendix A. These are primarily from material costs, as the Bollard Design Team did most of the manufacture. The total expenditures amounted to $141.83.

A machine shop owner (reference in Appendix C) was consulted as to the cost of manufacture of the bollard assembly. The details are shown in Appendix B. The total predicted cost is $339.77 (including one shear pin and a 20% contingency).

Recommendations

There are several key points that the client should consider before manufacturing and installing collapsible bollards based on the Bollard Design Team drawings and prototype. The first point to consider is that the bollard is designed to be a sustainable replacement for the current bollards already installed at UBC. It is designed to fit onto the in ground bases that have already been installed in the concrete. If the Bollard Design Team bollard is to be used in an entirely new location an in ground base would need to be installed. A preliminary design of an in ground base has been completed as shown on page H-14 of Appendix H. However, a prototype of this in ground base has not been built or tested.

The second recommendation regarding the bollard is that the shear pin size was chosen to allow the use of various size notches in order to provide a range of breaking strengths. This range includes forces lower than the current bollards installed at UBC up to forces approximately twice as high as the current bollards. The notches specified on page H-6 of Appendix H will provide a breaking force comparable to the current Maxiforce bollards. Decreasing the size of the notches would make the bollard more resistant to vandalism. The current bollards can be knocked over by vandals who kick it repeatedly. However, increasing the breaking strength would cause increased damage to vehicles hitting the bollard. The breaking strength of the current bollards and of the

Bollard Design Team bollards has been chosen to minimize damage to vehicles while providing adequate resistance to vandalism. Further, since the Bollard Design Team bollard stays attached to its base after being knocked over it is protected against theft in extreme cases of vandalism.

The third recommendation deals with the chain attachment mechanism which connects the bollard body to the base. The bolts which secure the chain on the prototype are fairly easy to take apart. This is because the prototype bollard is designed to be easily disassembled. When the bollard is installed for use at UBC or other locations the chain attachments may need to be protected against tampering. Simply tightening the bolt may be enough to prevent most people from tampering without the proper tools. However, a better method would be to use tamper proof bolts, loctite® thread adhesives or a combination of both. An alternate option is to weld the chain to the bollard base and the inside of the body tube, but this makes disassembly difficult.

Finally, the production of bollards should be based on the technical drawings provided. The prototype includes a couple of minor differences from these drawings. The major difference to note is that the prototype base includes a shoulder for the bollard body tube to pivot about during emergency disengagement. After testing, this shoulder was proven to be unnecessary so it has been excluded from the drawings. The removal of the shoulder reduces manufacturing complexity and cost.

Conclusions

The Bollard Design Team has gone through the entire engineering process of developing and building a product to meet given functional requirements. A working prototype has been built and addresses all problems that the existing design exhibits. The simplicity of the design results in a collapsible bollard that can be manufactured locally, and cheaply, without sacrificing quality. The total cost to make the bollard is approximately $340 CDN, which is about 30% of the price paid for the existing design. The force required to disengage the bollard is at least as much as for the current design, but not so much as to seriously damage a vehicle. Also, replacement of the shear component is easier and faster. After vehicle disengagement, the bollard stays attached to the ground, which is not the case for the existing design. Since the bollard can be manufactured locally, replacement parts are easy to obtain. Recommendations have been made that can be considered to pursue by the client, UBC Land and Building Services.

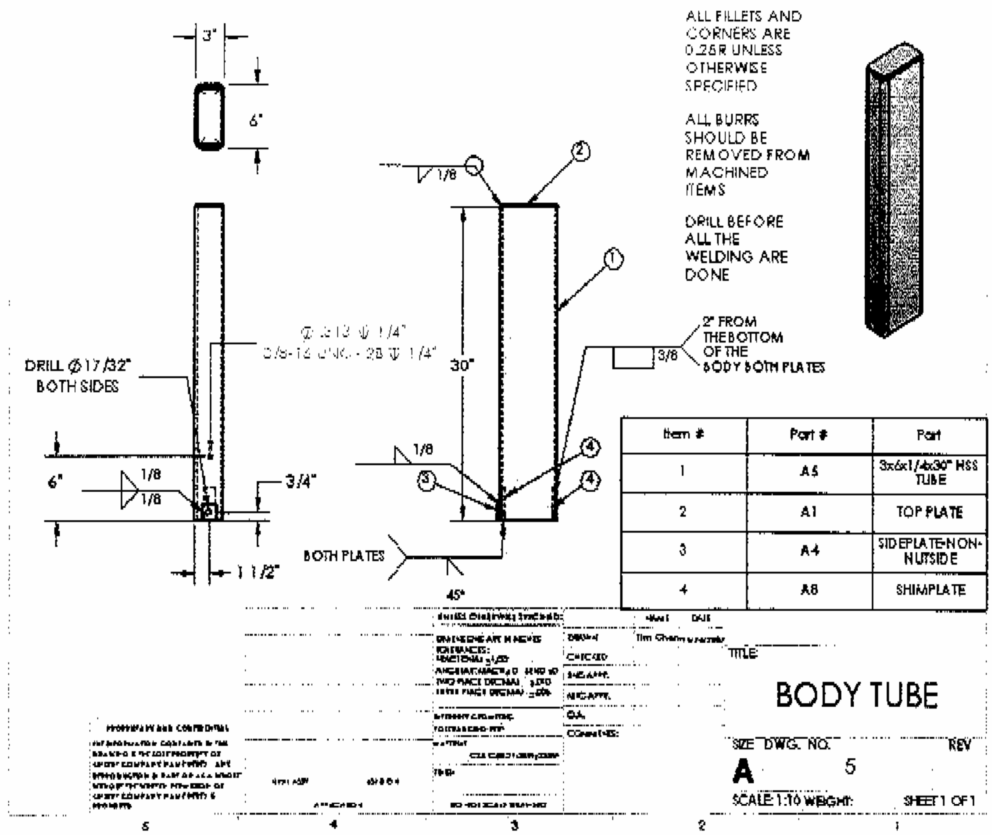
Appendix A – Project Expenses

Item	Cost ($CDN)
Aircraft Cable	3.52
Screw Pin Anchor	3.37
1/4 mall clipper	0.72
NLA (double swivel)	7.99
HSS TUBE 6x3x0.25 1@32"	66.73
CR SQUARE 1.5 1018 1@6"	9.53
HOTROLLED PLATE 0.25 1@5.75x2.75"	1.61
HR FLAT 0.75x6 1@3.5"	5.93
Test Pulley (1200lbs)	30.5
15' 3/16" steel cable	4.92
2 3/16" cable pinch clips	1.34
2 3/16" cable thimbles	0.67
Chain, two 1/4" bolts and nuts	~5
Total	$141.83

Appendix B – Cost Estimates for Manufacture

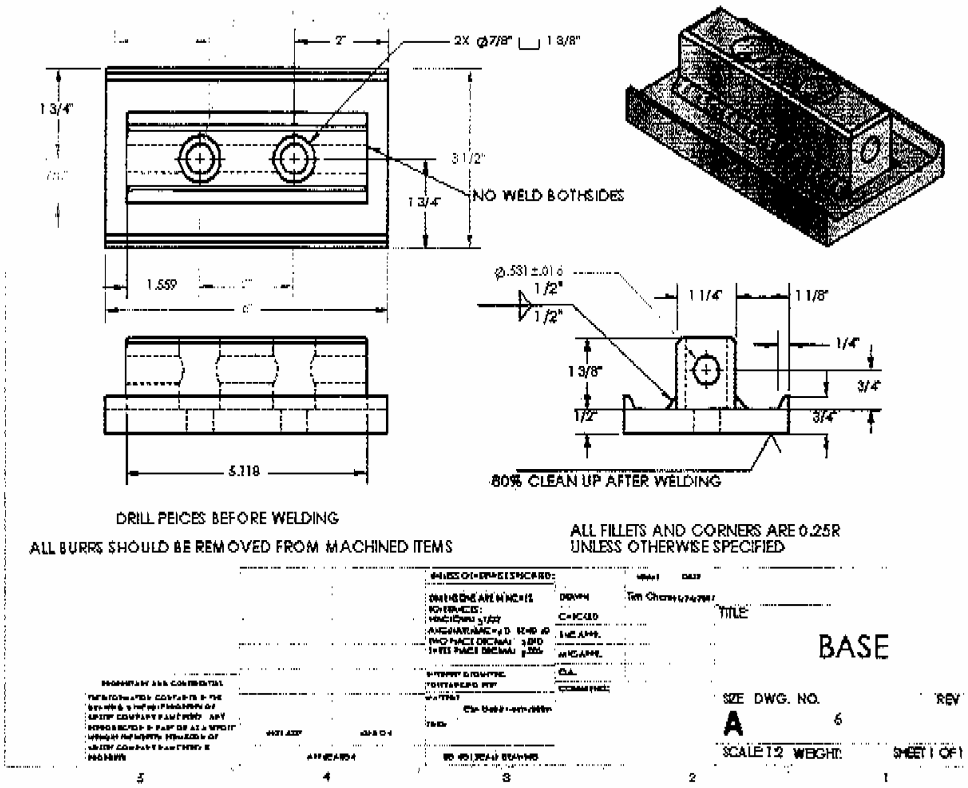
The following table is a summary of the costs to buy the materials for and manufacture the total assembly of the bollard. On subsequent pages are scans of the original estimates done by Pete Williams (reference contained in Appendix C), a machine shop owner.

Component	**Cost for Material and Manufacture ($CDN)**
Body Tube	147.10
Base	56.84
Side Plate	11.26
Top Plate	3.76
Nut	38.21
Spacer Plates	16.28
Shear Pin	9.69
Total	283.14
+20% Contingency	339.77



Item #	Part #	Part
1	A5	3x6x1/4x30" HSS TUBE
2	A1	TOP PLATE
3	A4	SIDEPLATE-NON-NUTSIDE
4	A8	SHIMPLATE

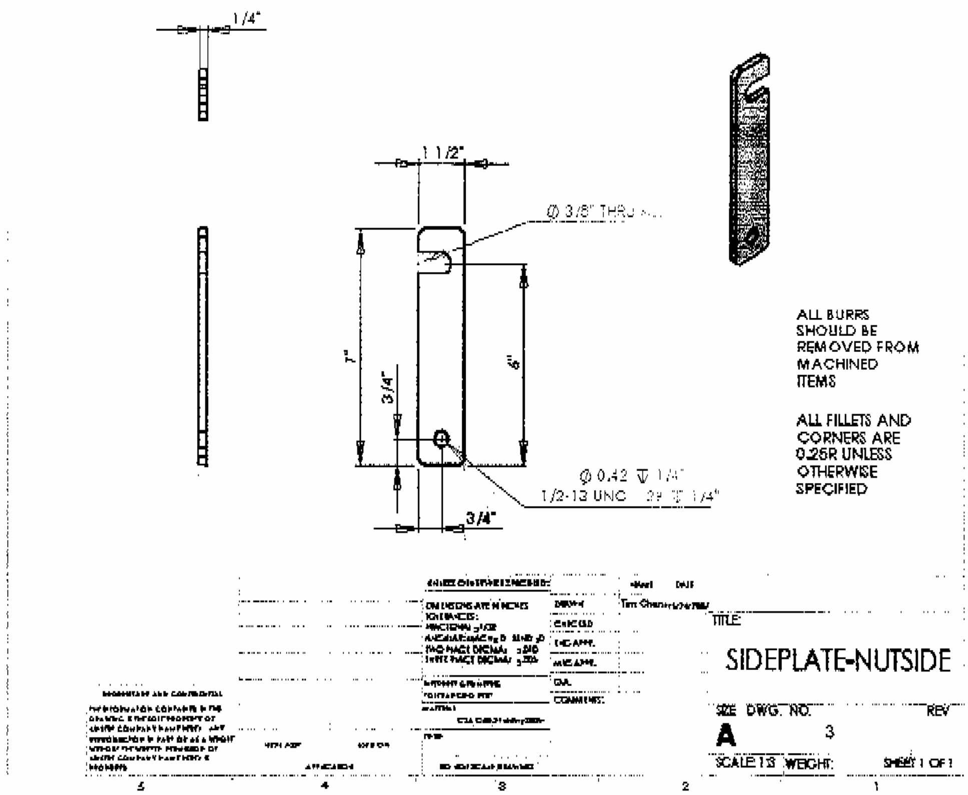
MAT'L TUBE 8.00 FT	$80.00
SAW	1.10
DRESS ENDS	2.50
DRILL (2) HOLES 17/32	10.00
DRILL & TAP 1/2 UNC	7.50
DRILL & TAP 3/8 UNC	7.00
WELD ITEMS TO BODY TUBE	39.00
	147.10
+20%	29.42
	176.52



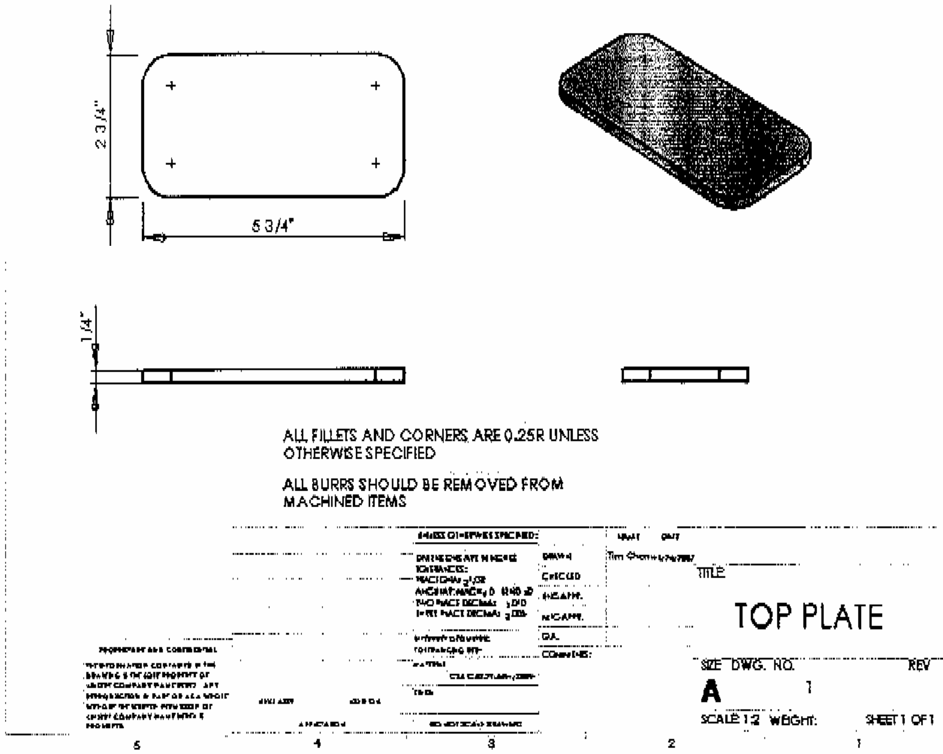
MAT'L 1/2" x 3 1/2 x 6' 3 lbs @ 2.00 lb. = 6.00
SAW .017 x 65.00 1.10
DRILL (2) HOLES THRU BASE .083 = 5.41
MAT'L 1 3/4 □ x 2.75 lbs @ 2.00 lb. = 5.50
DRILL (2) HOLES 7/8 THRU. = 6.00
DRILL (1) HOLE 17/32 THRU. = 8.50
WELD .166 x 65.00 = 10.83
MILL BASE TO 80% CLEAN-UP = 13.50

56.84
+20% CONTINGENCY 11.37

68.21



MAT'L 1½ x ¼ C1018 CR F/BAR x 7" = .75 lbs @ 2.00	$ 1.50
SAW .017 x 65.00	$ 1.10
MILL 3/8" SLOT, DRILL & TAP ½-13 UNC .1 x 65.00	$ 6.50
DRESS CORNERS .033 x 65.00	$ 2.16
	11.26
+20% CONT.	2.25
	13.51

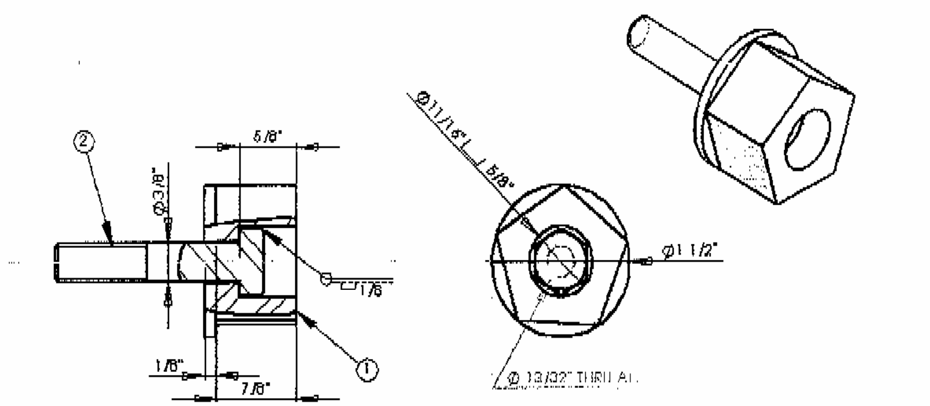


MAT'L 2 3/4 x 1/4 C1018 F|BAR = 1.13 lbs @ 2.00 = 2.46
HAND DRESS (4) PLACES RADIUS .020 x 65.00 = 1.30

3.76

+20% CONT .75

4.51



ITEM #	PART #	PART NAME
1	A7	NUT
2		3/8" - 16 - 2A UNC BOLT

ALL BURRS SHOULD BE REMOVED FROM MACHINED ITEMS

TITLE: NUT

SIZE A DWG. NO. 7 REV

SCALE 1:1 WEIGHT: SHEET 1 OF 1

SET-UP LATHE .5/15 .033 × 65.00 = 2.17

MAT'L 1½ C1018 CR. .5 lbs @ 2.00 = 1.00

LATHE :- DRILL, 11/16 HOLE & FLAT BOTTOM 5/8 DEEP, PART OFF. .134 × 65.00 = 8.71

SET-UP DIVIDING HEAD TO CUT (5) SIDED NUT = 2.17

CUT (5) SIDES OF NUT USING 1" SLOT DRILL .333 × 65.00 = 21.66

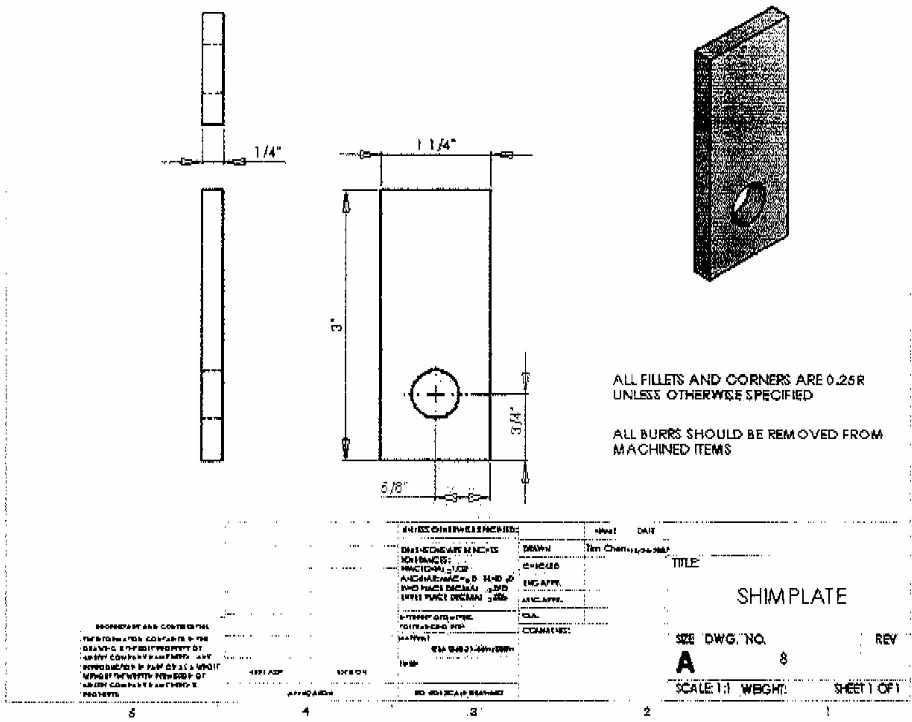
PLUG WELD BOLT TO NUT = 1.50

COST OF BOLT = 1.00

38.21

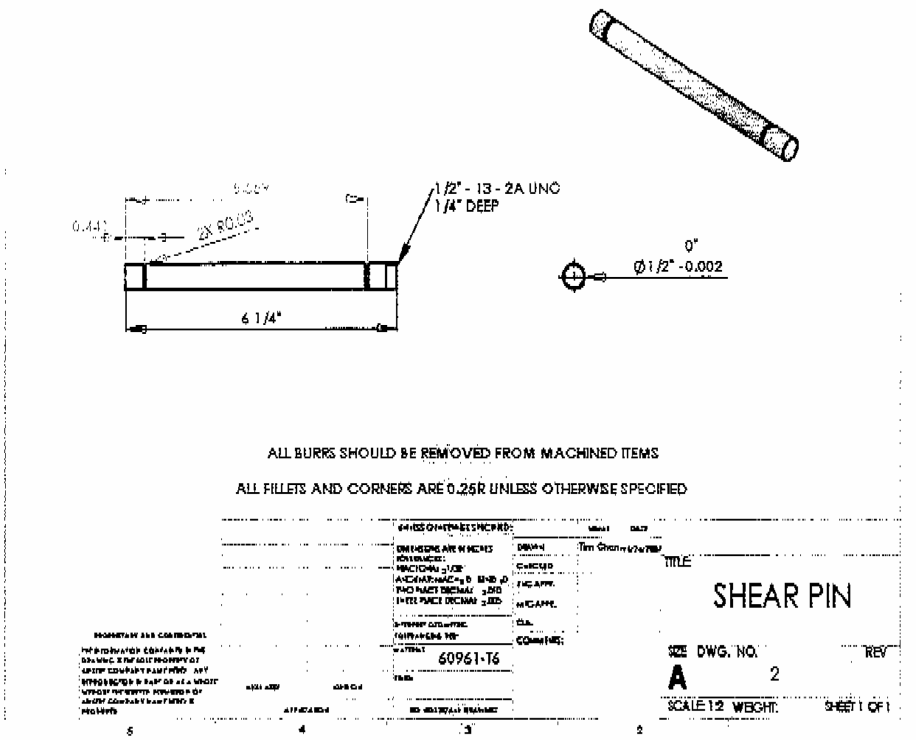
+20% CONT 7.64

45.85



MAT'L 1¼ x .25 C1018 F/BAR = .27 lbs @ $2.00 lb = .54
SAW .017 x 65.00 = 1.10
DRILL & REAM HOLE, DRESS .1 HRS @ $65 = 6.50

8.14
+20% 1.63
9.77 x 2



MAT'L .37 lbs @ 2.00 lb = .70
SET-UP LATHE .5/100 = .005 x $65.00 P/HOUR = .325
GROOVE/CUT THREAD & PART OFF .133 x 65 = 8.66

9.69 ea.
1.94

+20% CONT 11.63

Appendix C – References

The information for Pete Williams is as follows:

Western Vibration & Machine Services
Address : 6-19351 94 Avenue, Surrey, BC V4N 4E6
Telephone : 604-882-8933