TRI-LOC Joint Parting Test

Test Date: 15th June 2022

Prepared For: Trinity Products, 1969 West Terra Lane O' Fallon, MO 63366

July 12, 2022

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TRI-LOC
TRINITY PRODUCTS
MADE IN THE U.S.A.

July 12, 2022

Mr. Robert Griggs

Trinity Products, LLC.

1969 West Terra Lane,

O'Fallon,

MO 63366

RE: **TRI-LOC Joint Parting Test**

Dear Mr. Griggs

Kilduff Underground Engineering Inc. (KUE) is pleased to present to Trinity Products (TP) our report relative to the above test that was instigated in March 2022 and executed on 15th June 2022.

The concept of mechanically interlocked casings is innovative and potential applications moving forward is an exciting proposition. KUE is pleased to have worked with TP from concept to completion on this initial test and hope to remain involved with planned field trials moving forward together with tests on the new-patent-applied-for joint.

KILDUFF UNDERGROUND ENGINEERING, INC.

Paul Wilkinson

Senior Consultant

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1. BACKGROUND

Founded in 1979 Trinity Products (TP) has moved from steel broker to distributor to the largest USA based self-sufficient steel pipe manufacturer servicing the construction industries underground utility and piling contractors. Over the last seven years Trinity has also developed a unique mechanical casing joint, trade named TRI-LOC that mechanically interlocks steel casings, eliminating time consuming construction site joint welding procedures and providing a safer reduced risk working environment.

In September 2018 and in response to requests from clients to confirm the structural integrity of the TRI-LOC joint disassembly tests were undertaken at Louisiana Tech University that concluded in unsuccessful attempts to disengage four (4) interlocked TRI-LOC specimens with an axial load of 100 tons energized across the joints, the maximum practical force that could be generated by the test rig. Increasing the load to 120 tons on the final specimen resulted in failure of the rig. The trial proved inherent strength but did not identify potential limitations of an interlocked joint.

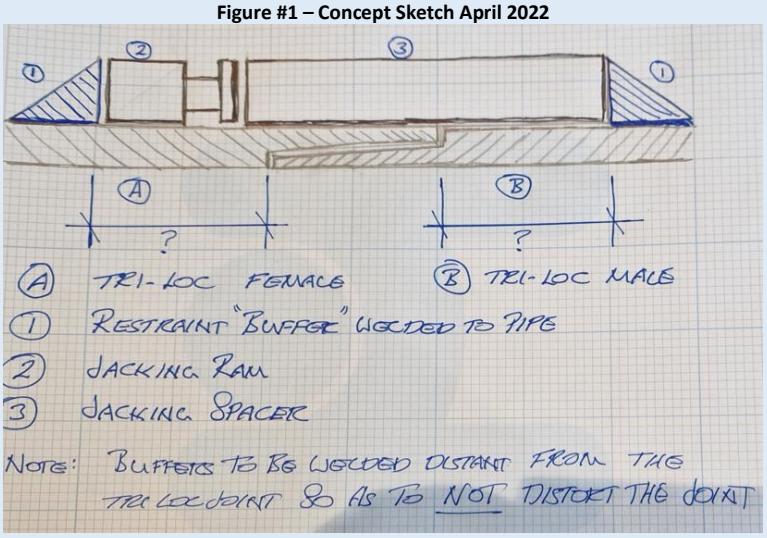
1.1 Introduction

Kilduff Underground Engineering (KUE) represent a relatively new to market trenchless technology manufactured by Geonex in Finland that installs steel cased tunnels through onerous rock and mixed ground with boulders.

The Geonex Horizontal Hammer Boring (HHB) system utilizes a pneumatic hammer that generates impact energy to breakdown ground at the tunnel face and drag sections of steel casing that are butt jointed welded together through the ground to achieve bores up to 400-ft in length.

KUE met with TP in March 2022 to outline the benefits of utilizing TRI-LOC joints with Geonex equipment. However, the proposition of pulling pipes through the ground brought back into question the ultimate disassembly strength of the joint. Following further discussions and a meeting in April 2022 TP decided to undertake a second joint disassembly test to finally establish the ultimate strength and potential suitability of using TRI-LOC joints with Geonex's HHB equipment. The test was to be undertaken generally in accordance with a concept provided by KUE that would be capable of energizing approximately 400 tons across an assembled joint as seen in Figure #1.

Figure #1 – Concept Sketch April 2022



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2. DESIGN & FABRICATION

2.1 Design Model

From the concept, TP's engineers identified suitable rams and produced a design model (Figures #2 & #3) to test an assembled 36-inch OD joint that was issued on 6th May 2022.

Figure #2 - Design Model

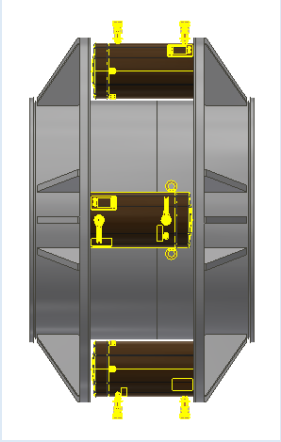
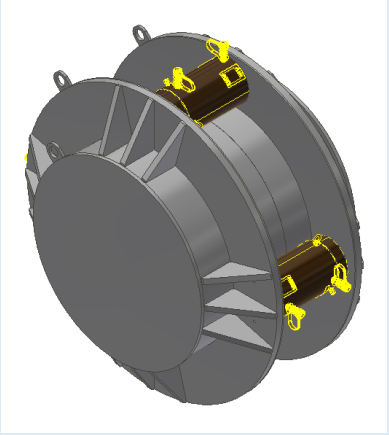


Figure #3 – Design Model

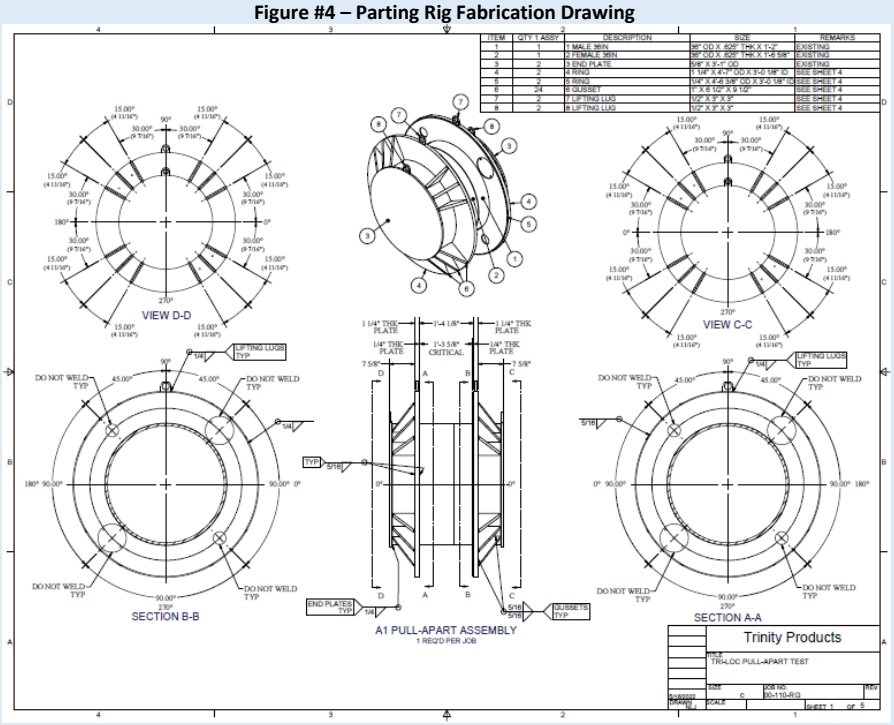


4 No. 168 ton capacity hydraulic cylinders positioned across an interlocked TRI-LOC joint
Rams equally and incrementally energized to achieve axial load disassembly

2.2 Fabrication Design

Following approval from the parties concerned design drawings for the test rig (Figure #4) were completed and issued for fabrication in May 2022.

Figure #4 – Parting Rig Fabrication Drawing



2.3 Rig Components

Economics of utilizing mechanical joints are particularly apparent with casings ≥ 36-inch outside diameter (OD), TP's recommended minimum wall thickness for a joint is 0.625-inch. The test rig was therefore designed to accommodate disassembly of a 36-inch OD x 0.625-inch wall thickness casing mechanically interlocked with a TL-AB 3-Tooth model TRI-LOC joint (Figure #5) with the following key components.

i. Casing Sections: 36-inch OD x 0.625-inch wall x 11-inch-long x 2 No.

ii. TRI-LOC Male Spigot: 36-inch OD x 0.625-inch nominal wall x 7.625-inch-long (Fig #5) x 1 No.

iii. TRI-LOC Female Coupler: 36-inch OD x 0.625-inch nominal wall x 7.625-inch-long (Fig #5) x 1 No.

iv. Casing End Plates x 2 No

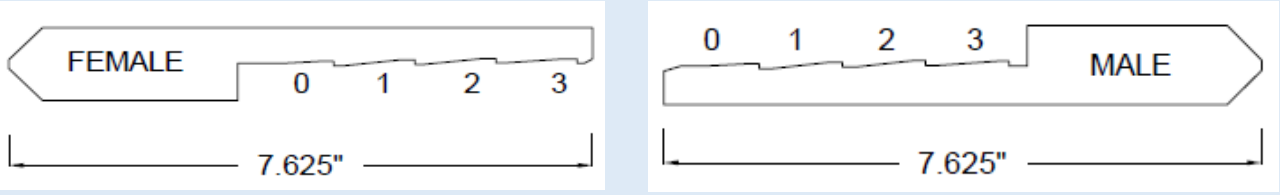
v. Thrust Rings and Reinforcement Gussets

vi. Hydraulic Thrust Rams – 4 No. 168 tons capacity x 5.91-inch stroke (capable of developing 672 tons of axial load across the joint)

vii. Hydraulic Feed / Return Hoses with Pressure Gauge x 4 sets

viii. Hydraulic Power Pack x 1 No

Figure #5 – TL-AB 3-Tooth Joint



2.4 Rig Assembly

Assembly of the test rig steelwork was undertaken in four stages

Stage 1: the TRI-LOC male spigot and female coupler were welded to the individual sections of casing.

Stage 2: the 37-inch OD end plates were welded to the plain the ends 36-inch OD casings

Stage 3: Urethane Seam Sealer was applied across male spigot mating surface to mimic construction site activities where sealant is applied to minimize passage of ground water across the joint. Following application, the casings with male spigot and female collar were "pressed" together to form a mechanically interlocked joint with an engagement pressure of 36,500 lbf (18.25 tons). Figures #6 to #10

Stage 4: the thrust rings and reinforcement gussets were welded to the mated casing

Figure #6 – Silicone Sealant

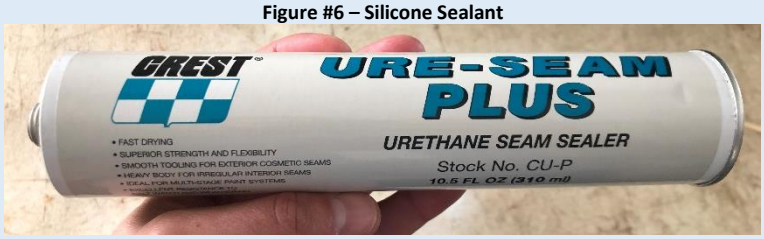


Figure #7 – Casing Assembly Graphic

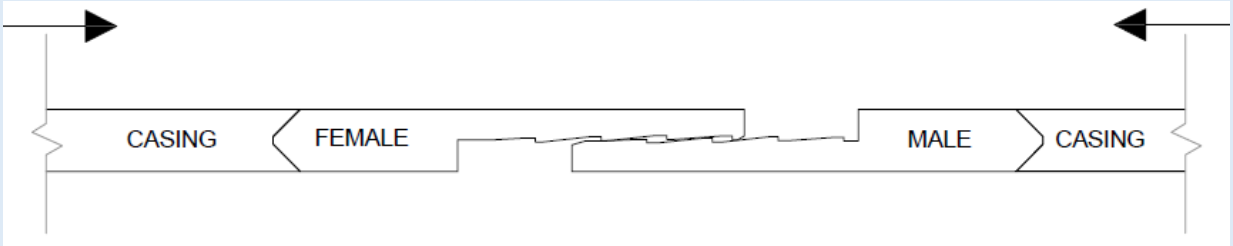
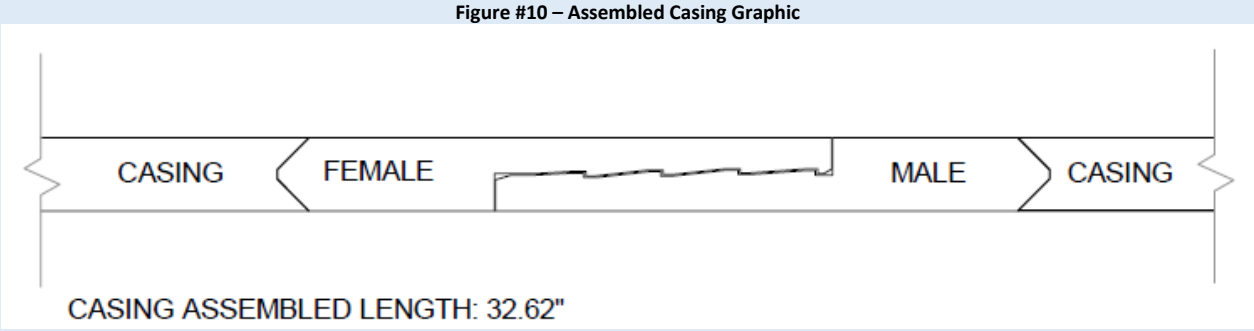


Figure #8 – Casing Assembly (silicone)

Figure #9 – Assembled Casing

Figure #10 – Assembled Casing Graphic



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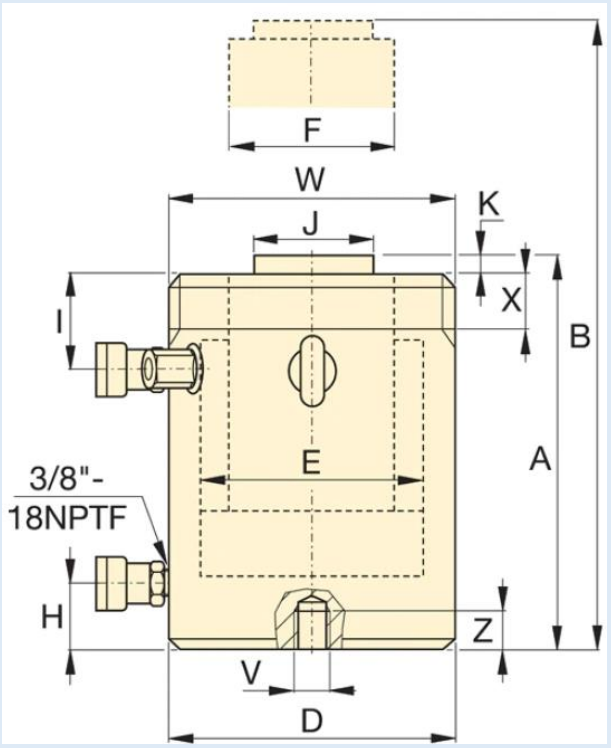
2.5 Jacking Equipment

Four hydraulic cylinders with specifications set out in Figure #11 together with a hydraulic power pack to energize the rams were sourced through the Enerpac Tool Group.

Figure #11 Hydraulic Rams Details



Maximum Operating Pressure (psi)	10,150
Maximum Cylinder Capacity Advance (tons)	168
Stroke (in)	5.91
Number of Cylinders (No.)	4
Total Maximum Capacity – 4 No. Cylinders @ 10,150 psi (tons)	**672**
Collapsed Height A (in)	12.6
Extended Height B (in)	18.5

3. JOINT PARTING TEST

On Wednesday June 15th, 2022, KUE attended Trinity's O'Fallon, MO factory to finalize procedures and witness the joint parting test.

3.1. Final Assembly

Final assembly of the rams to the test rig together with connecting of hydraulic feed hoses from the power pack via pressure gauges to the jacking rams and return hoses from the rams to the power pack was undertaken during the morning of 15th June 2022 and can be seen in Figures #12 to #14

Figure #12 - Ram Assembly

Figure #13 - Hosed Ram Connections

Figure #14 Hydraulic Power Pack, Pressure Gauges & Hydraulic Feed & Return Lines

3.2. Test Procedure

The following criteria were set out and agreed to for undertaking the test.

i) Axial load across the joint would be increased in 20-ton increments to the level of 100-tons, the threshold of the Louisiana Tech test and in 10-ton increments thereafter.

ii) Following each increase incremental increase in load the pressure would be held for 30 seconds to allow the joint to be visually inspected and recorded

iii) The cycle of incrementally increasing then holding load would be repeated to the point of joint failure.

3.3. Test & Test Results

The joint parting test commenced at 11:47 am with loading incrementally increased 32 times over a period of approximately 21 minutes, with the following recorded milestones.

iv) Load Increment #7 with 120 tons of load across the joint (Figure #15)
- Minor 1/32" opening

v) Load increment #27 with 280 tons of load across the joint (Figure #16)
- Heard creaking but no movement

vi) Load increment #32 whilst applying pressure to increase axial load from 360 tons to 370 tons (Figure #17)
- Minor opening grew for approximately 5 to 10 seconds followed by a loud bang signaling joint failure

Figure #15 – 120 tons

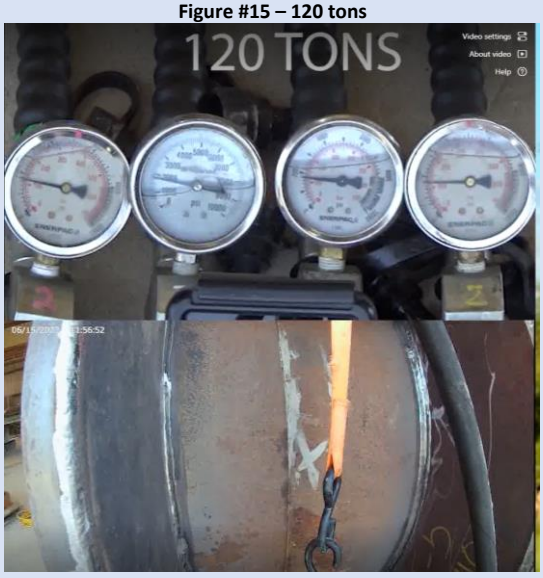


Figure #16 – 280 tons

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Figure #17 – 360 tons

Figure #18 – Joint Failure (top)

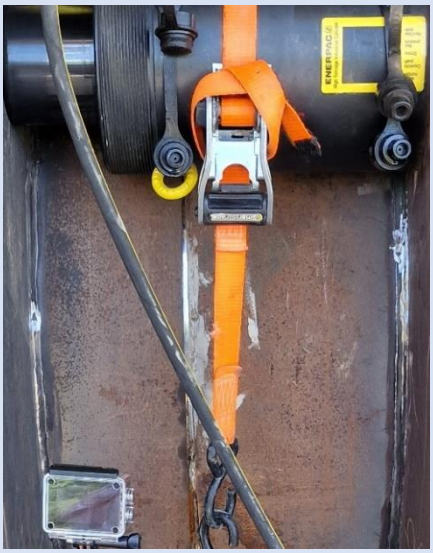
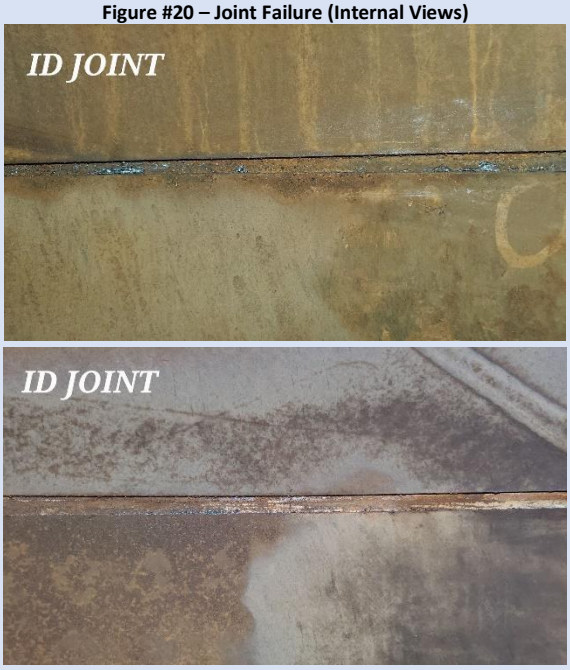


Figure #19 – Joint Failure (bottom)

Figure #20 – Joint Failure (Internal Views)



Full test data can be found in Appendix 1

The link below contains photographs and videos from the test.

https://photos.app.goo.gl/SfA6whKed6L8ybcj7

3.4. Disassembled Joint - Inspection

Parting of the casings revealed ripped steel at tooth engagement steps developed at the point of disengagement and chafed surfaces a product of lateral movement following disengagement of the joint.

Figure #19 – Parted Male Spigot

4. RESULT & CONCLUSIONS

The Louisiana Tech test in 2018 concluded in failure to disengaged 4 (four) pre-assemble TRI-LOC joints, results with more questions than answers. However, it did identify TRI-LOC joints are not weak and exhibit tensile strengths > 100 tons.

The examination on 15th June 2022 took testing to a higher level, concluding in successful disengagement with > 360 tons of lateral axial load applied across the joint, 300% more than had previously been mobilized that marks the strength of the joint to be commendably high and provides a benchmark for the ultimate strength of the Model TL-AB 3-Tooth joint. Scientific information that can be broadcast to company personnel and publicized to the wider trenchless industry.

5. NEXT STEPS

In relation to use of the TRI-LOC joint with Geonex's HHB equipment that drags casings through the ground the result is positive and paves the way to move from scientific to field trial evaluations both in the USA and Europe.

We look forward to reporting on results from the forthcoming 16-inch field trial with EBI Drilling Services from Duluth MN in approximately 3-weeks' time together with future tests on the new patented-applied-for joint that proffers augmented interlocks and post engagement dowel pin fixings.

Appendix 1

Joint Parting Test Recorded Data

36-inch TRI-LOC Joint

Model TL-AB 3-Tooth

Trinity Products Factory, 1969 West Terra Lane O'Fallon, MO 63366

15th June 2022

Ram Maximum Operation Pressure (psi)		**10150**
Ram Maximum Advance Capacity		**168**
Number of Rams		**4**

Loading Increment No.	Tons /Ram	Applied Tonnage	Load Build (tons)	Pressure Build (psi)	Hold time (secs)	NOTES
1	5	20		302	30	start at 11:47
2	10	40	20	604	30	11:53 - no movement
3	15	60	20	906	30	11:54 - no movement
4	20	80	20	1208	30	11:54 - no movement
5	25	100	20	1510	30	11:55 - no movement
6	27.5	110	10	1661	30	11:55 - no movement
7	**30**	**120**	**10**	**1813**	**30**	**11:56 1/32" gap**
8	32.5	130	10	1964	30	11:57 - no movement
9	35	140	10	2115	30	11:58 - no movement
10	37.5	150	10	2266	30	11:58 - no movement
11	40	160	10	2417	30	11:59 - no movement
12	42.5	170	10	2568	30	12:00 - no movement
13	45	180	10	2719	30	12:00 - no movement
14	47.5	190	10	2870	30	12:01 - no movement
15	50	200	10	3021	30	12:01 - no movement
16	52.5	210	10	3172	30	12:02 - no movement
17	55	220	10	3323	30	12:02 - no movement
18	57.5	230	10	3474	30	12:03 - no movement
19	60	240	10	3625	30	12:03 - no movement
20	62.5	250	10	3776	30	skipping to 3900 psi
21	65	260	10	3927	30	12:04 - no movement
22	67.5	270	10	4078	30	skipping to 4200 psi
23	**70**	**280**	**10**	**4229**	**30**	**12:05 - no movement. Heard creaking**
24	72.5	290	10	4380	30	skipping to 4500 psi
25	75	300	10	4531	30	12:05 - no movement
26	77.5	310	10	4682	30	skipping to 4800 psi
27	80	320	10	4833	30	12:06 - no movement
28	82.5	330	10	4984	30	skipping to 5100 psi
29	85	340	10	5135	30	12:07 - no movement
30	87.5	350	10	5286	30	skipping to 5400 psi
31	90	360	10	5438	30	12:08 - no movement
32	***?***	***360+***	***?***	***?***	***?***	**Re-applying pressure to move to 370 tons of load Gap grew slowly for 5 to 10 seconds before LOUD BANG, 3/4" gap at bottom, 1/8" gap at top**

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