



### Scope

Aftermarket replacement Window Regulators for OE part number 51 33 7 020 659 and 51 33 7 020 660, sold by company noted as BRAND X, were reviewed using the tools, measurement equipment and quality verification processes in use at APA Industries. This report itemizes non-conformances found with the BRAND X Window Regulator when compared to regulators 51 33 7 020 659 and 51 33 7 020 660 from the original equipment manufacturer (OEM) and URO Parts.

### Part Numbers

- OEM:** 51 33 7 020 659, 51 33 7 020 660
- BRAND X:** Proprietary (cross references to 51337020659, 51337020660)
- URO PARTS:** 51 33 7 020 659-PRM, 51 33 7 020 660-PRM

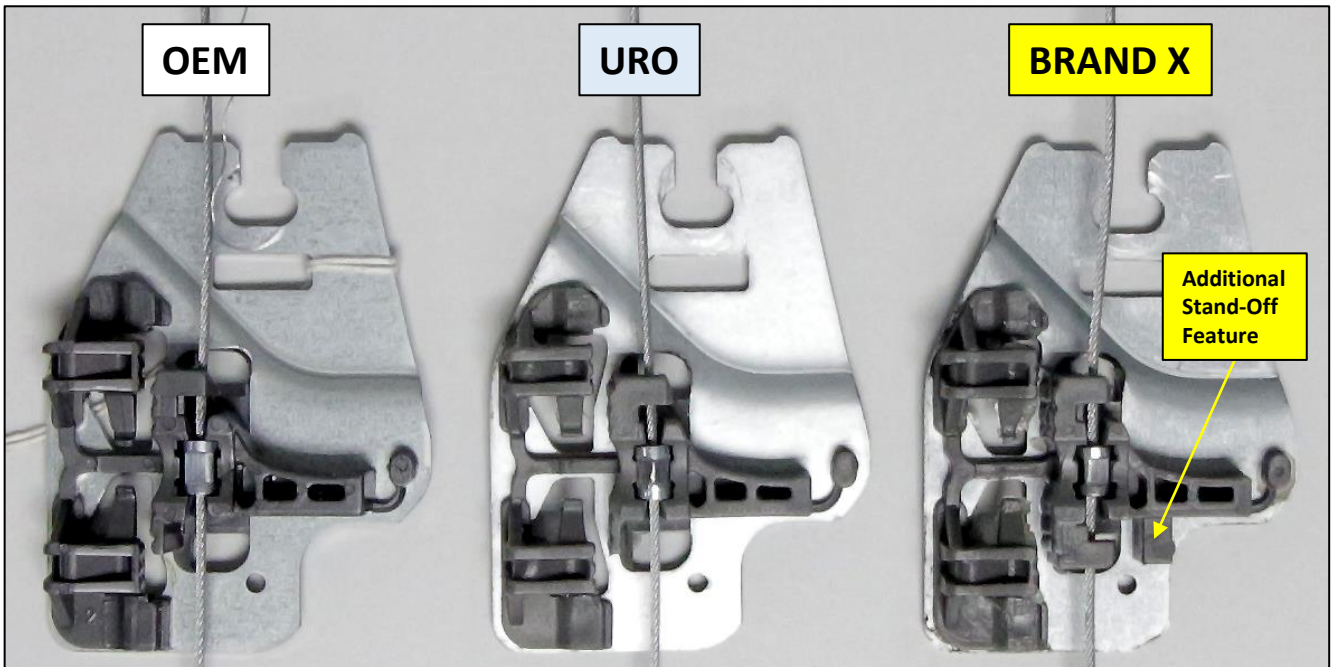
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### Findings

- Basic components of both BRAND X and URO regulators match the OEM offering.
- BRAND X and OEM regulators had plastic pulleys that rotate on a steel pin. Once the factory-applied pin lubricant escapes or evaporates, plastic pulleys can wear against the metal pins, increasing friction and lateral runout as pivot holes are enlarged.
- The URO regulator utilized a plastic pulley fitted with an integrated ball bearing. Ball bearings reduce friction when the cable and pulley are highly tensioned during window operation, especially when seals are contaminated with sticky environmental substances such as tree sap, or are frozen to the glass due to snow or freezing rain. Bearing pulleys are stronger and less dependent on lubricant compared to plastic-on-steel pulleys.
- The BRAND X cable averaged only 50.8% of the preload tension of the OEM cable, and only 60.7% of the tension of the URO cable. Cable preload retains the cable in the pulley grooves during window operation. If the window glass sticks in position, actuating the electric motor dramatically increases cable tension in the drive direction while substantially reducing tension on the slack side of the cable assembly. If cable preload is inadequate to absorb the slack, the cable can slip out of the pulley groove, resulting in window regulator assembly failure.
- The BRAND X cable was 37.5% weaker than the OE cable and 25.7% weaker than the URO cable in the Force to Failure Test. If the cable strength isn't adequate to withstand drive motor tension (especially when the glass resists movement), the cable wires can fray or snap, resulting in failure of the window regulator assembly.
- The URO cable was the same diameter as OEM, and had the same number of wires in the primary and secondary cables.
- Regulators were mounted into an OE door assembly for dynamic testing and window stroke measurement. Due to interference at the rear slider, BRAND X had approximately 5mm less window travel compared to OEM and URO, resulting in the glass protruding from the door window sill in an unsightly and uncomfortable manner should a vehicle occupant attempt to rest an arm on the window sill.
- The motor drive spline ID in the BRAND X regulator was 0.44mm larger than OEM, and 0.50mm larger than URO. Looser spline tolerance increases motor drive backlash, increasing the momentary delay when reversing window direction.

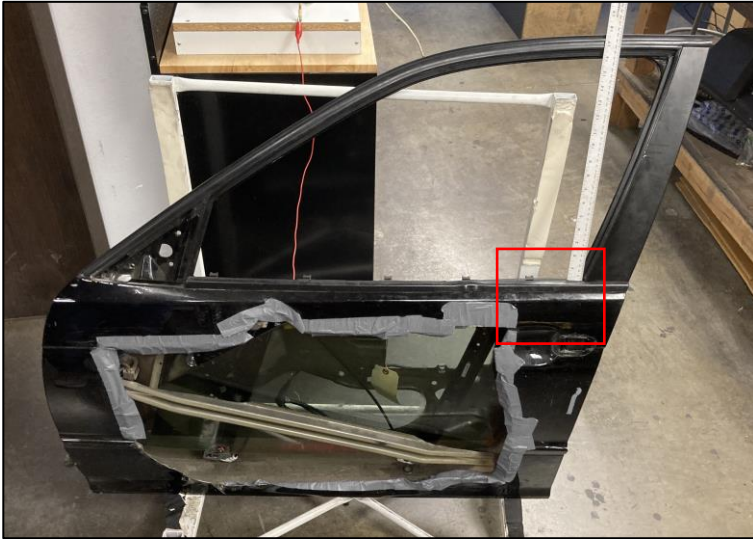
### Key Features: Rear Slider (Window Mount)



### Slider Notes:

URO Slider matches the OEM. BRAND X Slider has an additional Stand-off Feature.

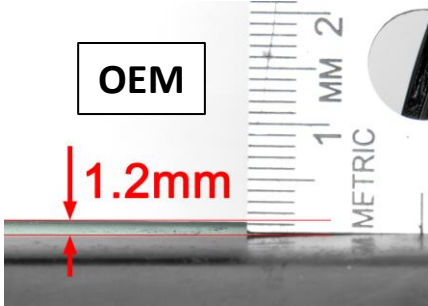
### Key Features: Slider, Regulator Test Fit, Full Down Position Difference



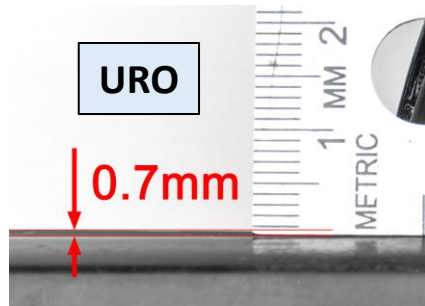
#### Door Assembly Test Fit Notes:

The OEM & URO window regulators position the window glass almost flush with the top of the glass wiper seals (near the B pillar) when in the full-down position.

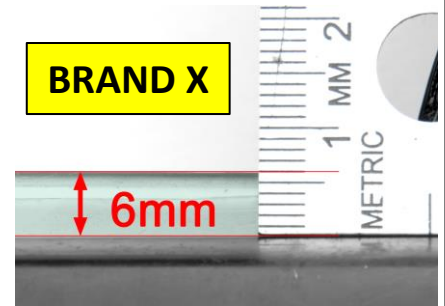
The BRAND X regulator leaves ~6mm of window glass protruding from the wiper seals when window is fully lowered, which can be unsightly and make resting an arm on the window sill uncomfortable. The glass protrusion is caused by a stand-off feature located on the back of the BRAND X Slider.



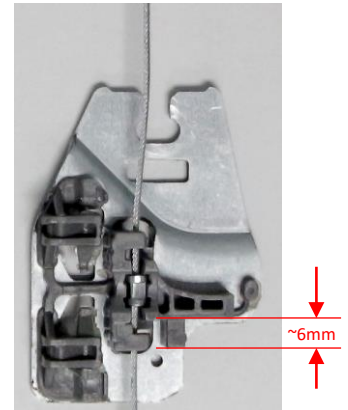
OEM regulator installed in the test door assembly. About 1.2mm of window glass is still visible near the B pillar when in the full-down position.



URO regulator installed in the test door assembly. About 0.7mm of window glass is visible near the B pillar when in full-down position.



BRAND X regulator installed in the test assembly. About 6mm of window glass is visible near the B pillar when in full-down position.

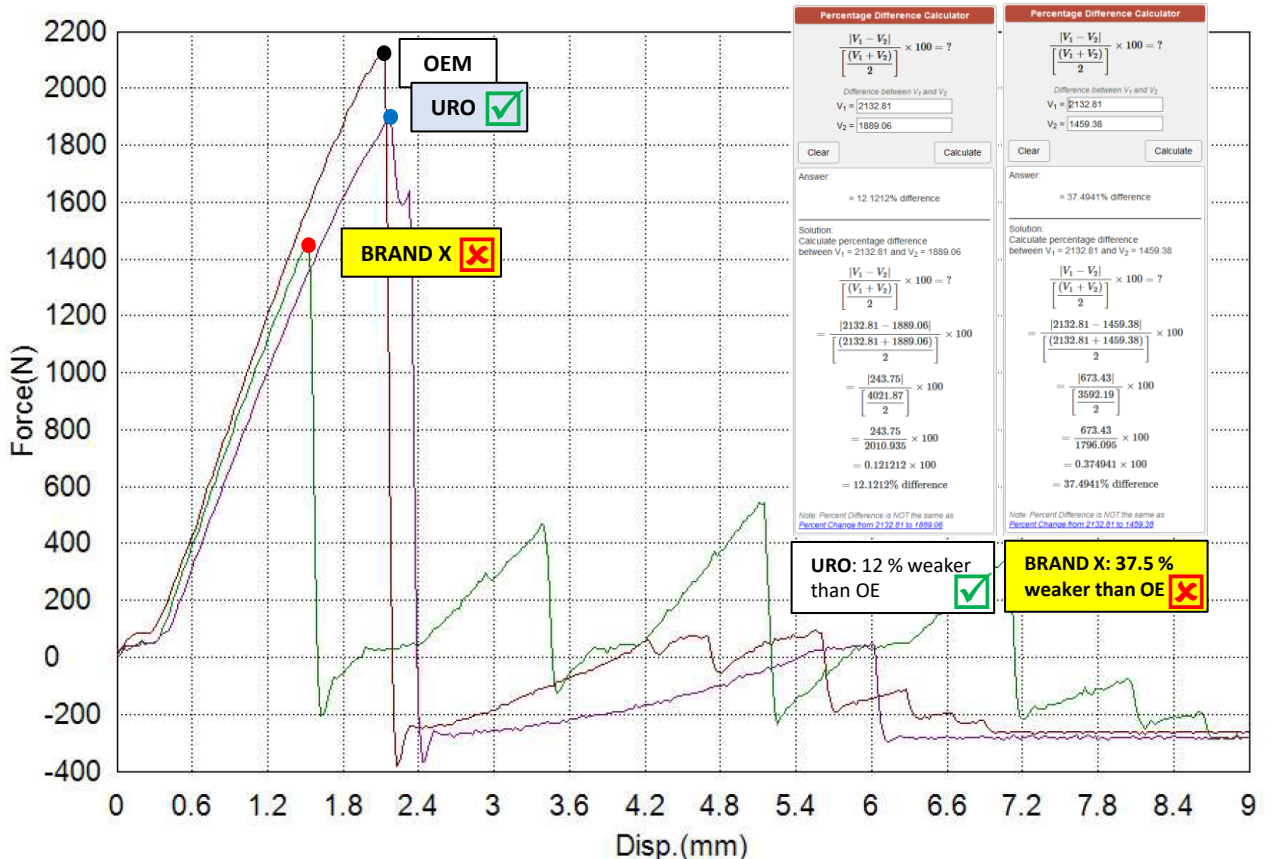


**Key Features:** Cable Tension Force to Failure Testing

### Window Regulator Cable Tension Test

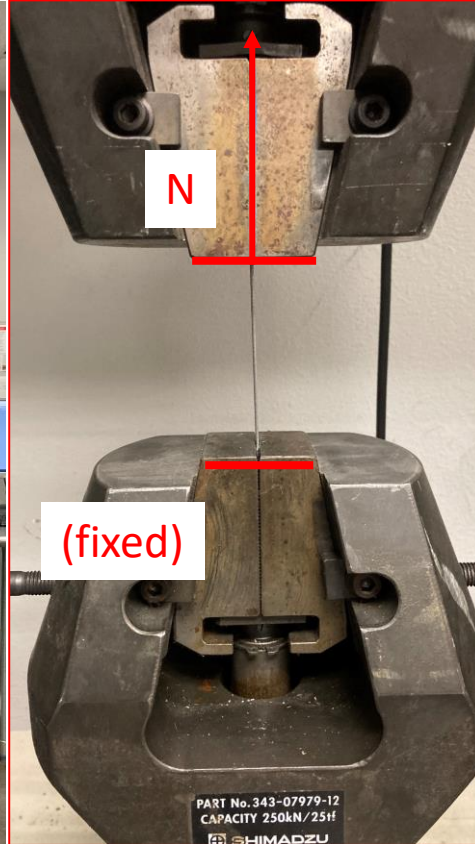
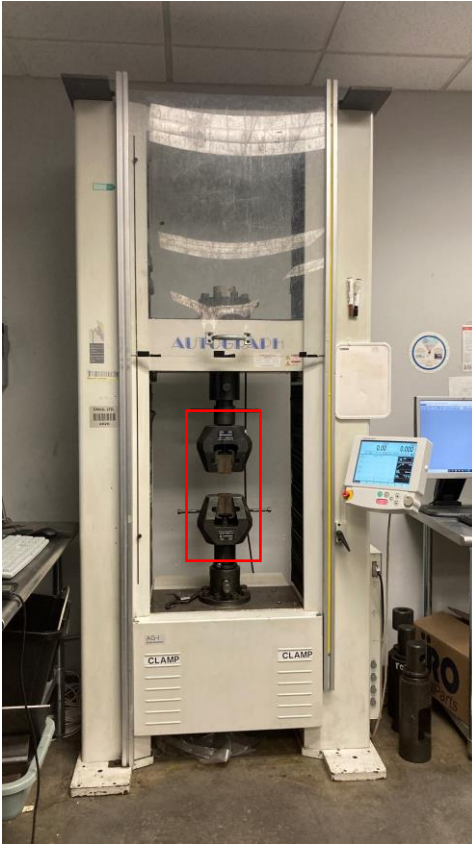
Key Word		Product Name	
Test File Name	Cable Tension Test.xtai	Method File Name	MB Tension 100mm_window reg cable.xmai
Report Date	5/5/2017	Test Date	6/24/2017
Test Mode	Single	Test Type	Tensile
Speed	30mm/min	Shape	Rod
No of Batches:	4	Qty/Batch:	1

Name	Elastic	Max_Force	Break_Force	LASE1_Force
Parameters	Force 10 – 20 N	Calc. at Entire Areas	Sensitivity: 10	Stroke 0.5 mm
Unit	N/mm2	N	N	N
OE 200	37536.5	2132.81	2132.81	317.938
URO	107761	1889.06	1639.06	194.813
Brand X	--	1459.38	1459.38	259.375



### Key Features: Cable Tension Force to Failure Testing

### Test Setup Pictures



### URO vs BRAND X % Difference

#### Percentage Difference Calculator

$$\frac{|V_1 - V_2|}{\left(\frac{V_1 + V_2}{2}\right)} \times 100 = ?$$

Difference between  $V_1$  and  $V_2$

$V_1 = 1889.06$

$V_2 = 1459.38$

Clear

Calculate

Answer:

= 25.6645% difference

Solution:

Calculate percentage difference between  $V_1 = 1889.06$  and  $V_2 = 1459.38$

$$\begin{aligned} & \frac{|V_1 - V_2|}{\left(\frac{V_1 + V_2}{2}\right)} \times 100 = ? \\ & = \frac{|1889.06 - 1459.38|}{\left(\frac{1889.06 + 1459.38}{2}\right)} \times 100 \\ & = \frac{429.68}{3348.44} \times 100 \\ & = \frac{429.68}{1674.22} \times 100 \\ & = 0.256645 \times 100 \\ & = 25.6645\% \text{ difference} \end{aligned}$$

Note: Percent Difference is NOT the same as

### RESULTS:

#### Compared to the OE Tension at Failure:

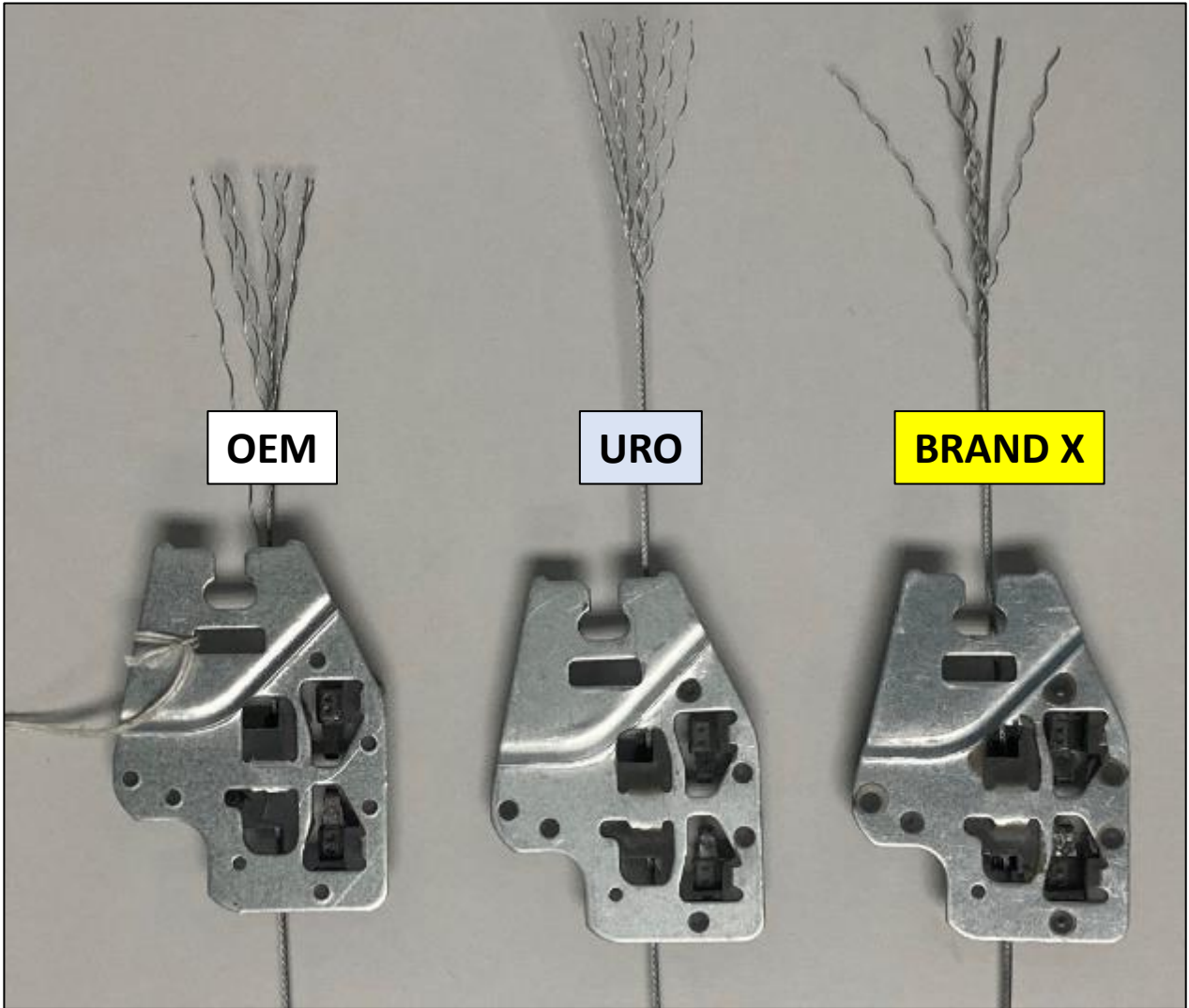
The **BRAND X** Cable failed at 1459 N of tension, **37.5% lower** than the OE at 2132.8 N

The **URO** Cable failed at 1889 N of tension, 12.1% lower than the OE at 2132.8 N

#### URO Compared to BRAND X:

The **URO** Cable is **25.7% stronger** than the BRAND X Cable.

**Key Features:** Cable Assembly



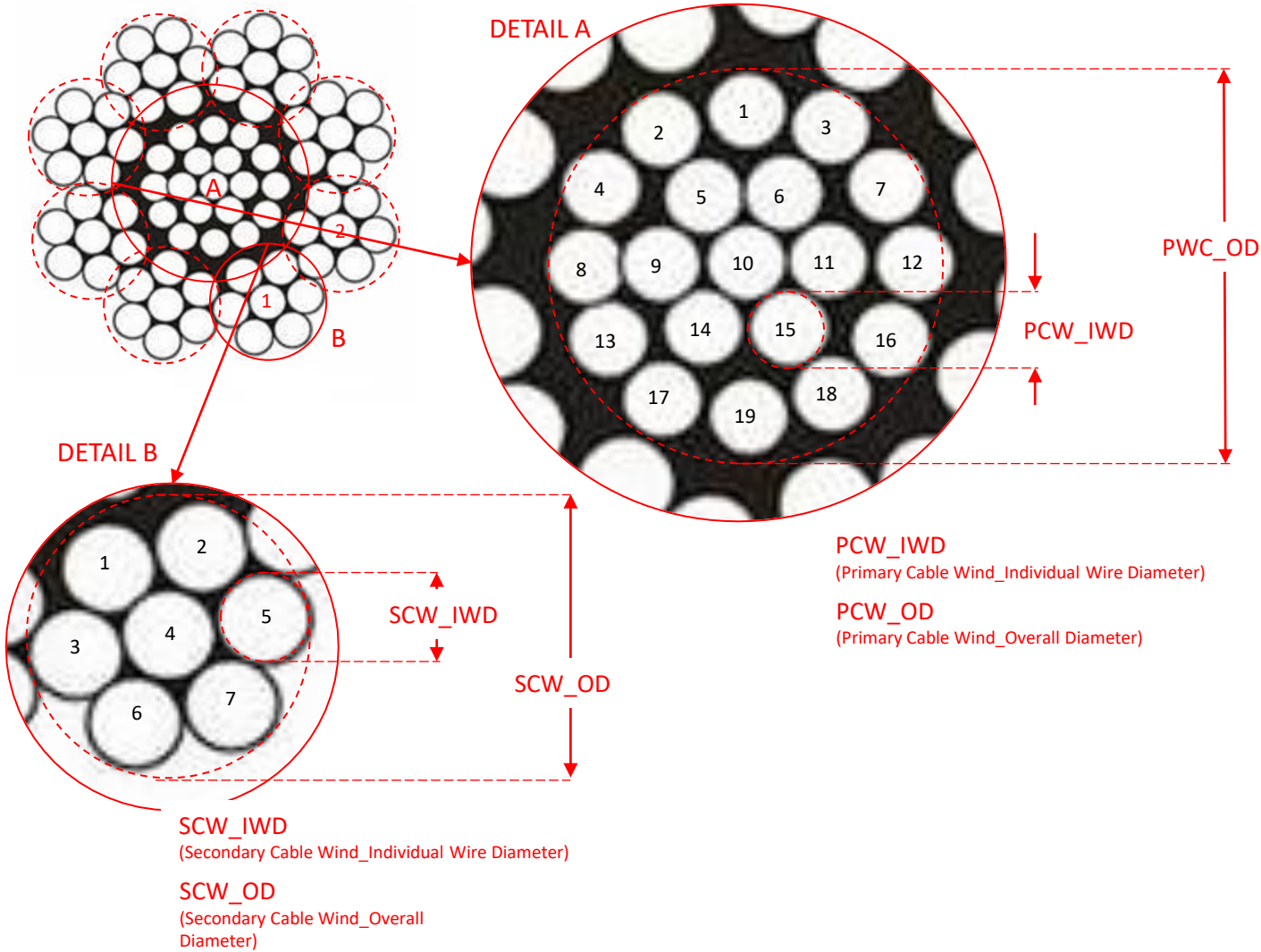
Part	Overall Diameter	Primary Cable			Secondary Cable		
		# of Wires	Diameter	Winds/Inch	# of Wires	Diameter	Winds/Inch
OE	1.45	1	0.71	2	8	0.41	4
URO	1.45	1	0.71	2	8	0.41	5
BRAND X	1.52	1	0.70	2.5	8	0.41	5

**Cable Notes:**

The Overall Diameter of the BRAND X Cable is larger than the OE and the URO, which is caused by an additional ½ wind per inch.

### Key Features: Cable Dimensions Detail

Cable Diagram



#### Secondary Cable Wind (SCW): 7-Wire Cable

	OE	URO	BRAND X
SCW_OD	0.41	0.39	0.39
SCW_IWD	0.12	0.11	0.11
No. of Wires	7	7	7

#### Primary Cable Wind (PCW): 19-Wire Cable

	OE	URO	BRAND X
PCW_OD	0.70	0.70	0.70
PCW_IWD	0.12	0.11	0.10
No. of Wires	19	19	19

#### Cable Notes:

Cable dimensions and assemblies all match.



**Key Features:** Cable Material XRF Testing

OEM

URO

BRAND X

CAUTION HIGH INTENSITY X-RAY BEAM

# 9226 General Metals

NAV Tools

Time 31.5 sec

No Match 7.2

OE

Ele	%	±1σ
Fe	50.85	0.23
Zn	33.43	0.34
Si	7.18	0.12
Nb	2.97	0.07
Al*	2.52	0.32
Mo	1.08	0.07
Zr	0.612	0.030

CAUTION HIGH INTENSITY X-RAY BEAM

# 9227 General Metals

NAV Tools

Time 31.1 sec

No Match 6.4

URO

Ele	%	±1σ
Fe	47.00	0.15
Zn	45.44	0.31
Si	3.52	0.07
Al	1.43	0.19
Nb	0.877	0.036
S	0.453	0.017
Mn	0.277	0.029

CAUTION HIGH INTENSITY X-RAY BEAM

# 9228 General Metals

NAV Tools

Time 30.6 sec

No Match 6.4

Dorman

Ele	%	±1σ
Fe	55.58	0.17
Zn	37.74	0.29
Si	3.01	0.06
Al	1.58	0.20
Nb	0.874	0.040
Mn	0.282	0.032
S	0.248	0.012

### Material Testing Notes:

All of the cables have similar material composition, with the primary element being Iron (Fe) and the secondary being Zinc (Zn) for strength and weather resistance, respectively.

### Key Features: Pulley

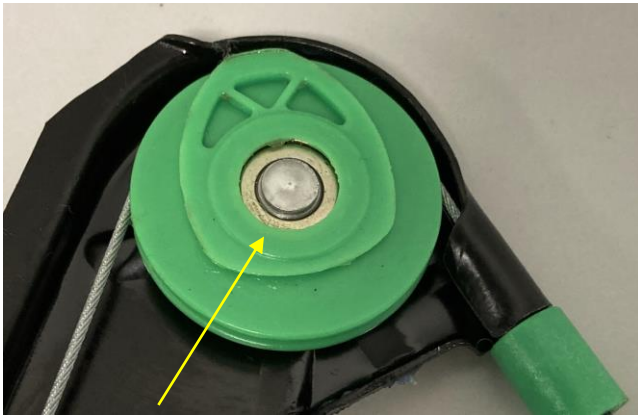
The Pulley in the URO regulator has an integrated **ball-bearing** assembly to reduce rotational friction and increase the strength of the pulley.

#### OEM



**OEM Pulley:** Green plastic Pulley pinned to steel frame, lubricated with grease.

#### URO



**URO Pulley:** Green plastic Pulley with integrated **Ball-Bearing**, which reduces friction and increases strength in rotational axis. Upgraded assembly compared to OE.

#### BRAND X



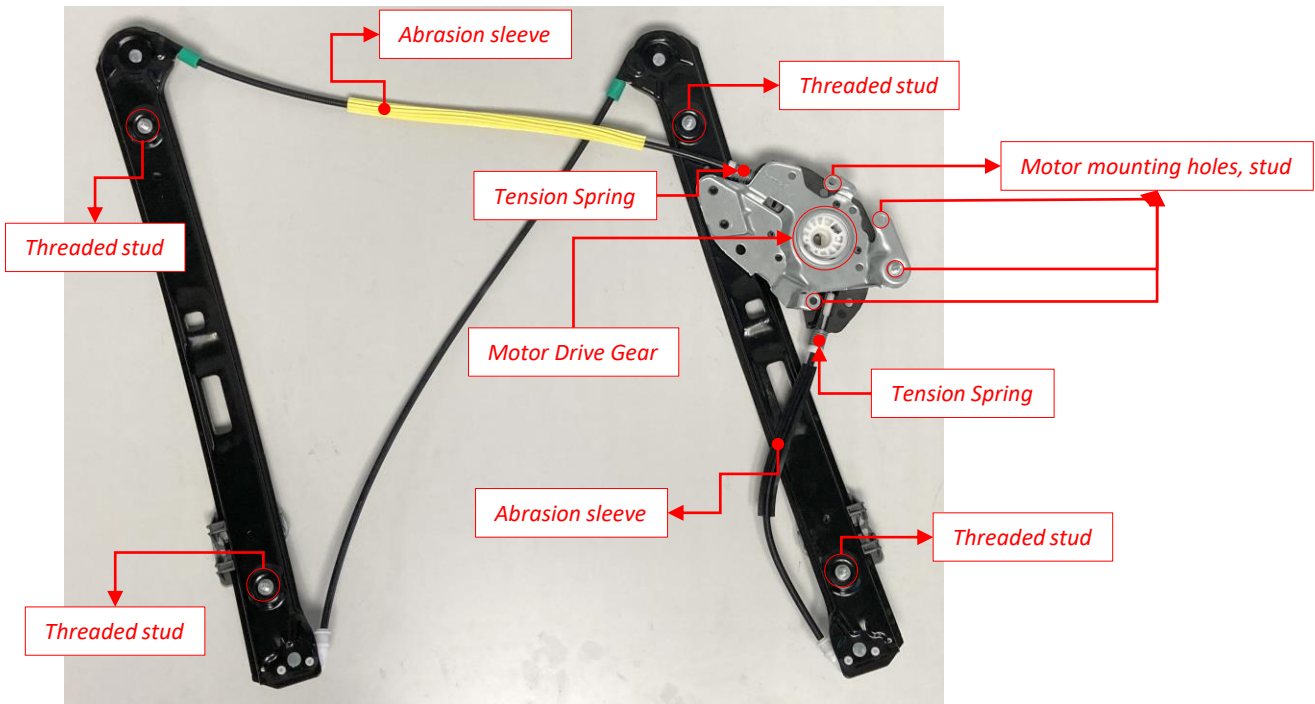
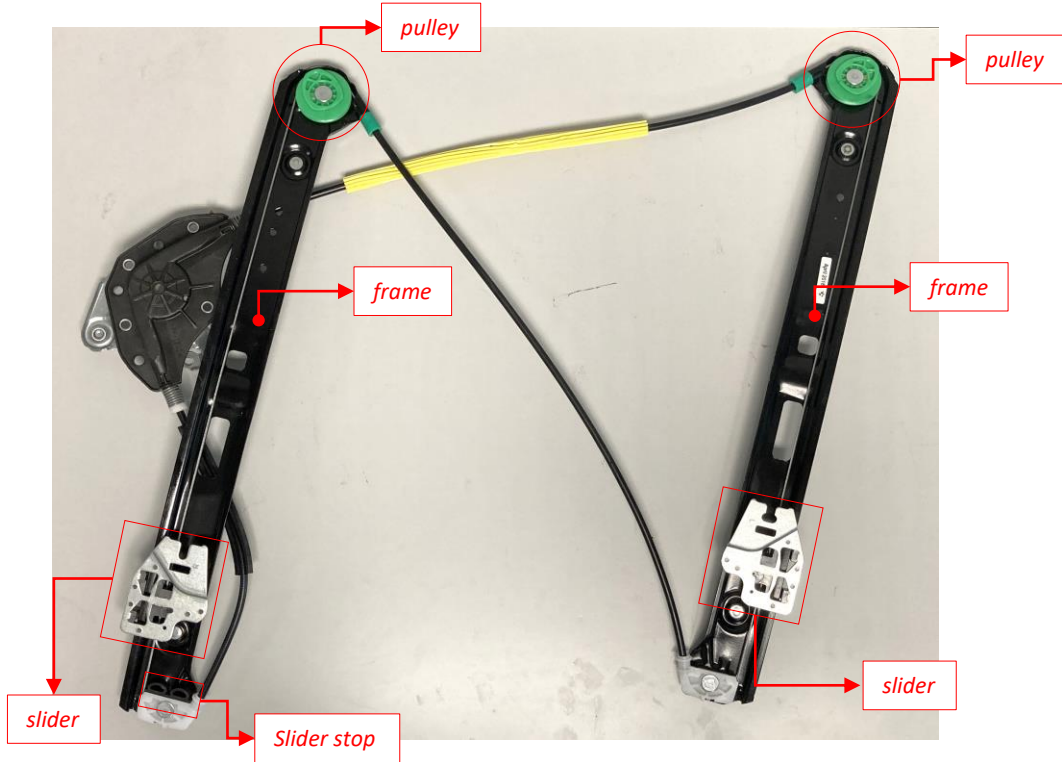
**BRAND X Pulley:** Standard offering green plastic Pulley, pinned to steel frame, lubricated with grease.

### Pulley Notes:

URO regulator has 1x upgraded ball bearing assembly integrated into the pulley to increase strength and reduce friction when cable is tensioned.




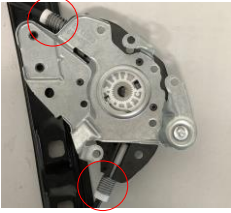
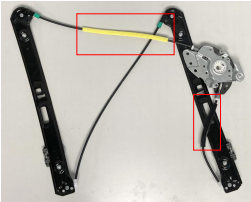
### OEM Regulator: Standard Component Diagram

The URO part and the BRAND X Part have the same components as the OE.






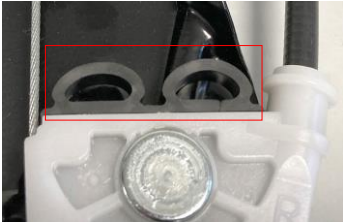
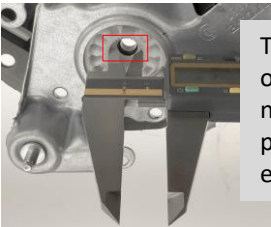
### Component Review Table:

The URO part and the BRAND X part have the same components as the OE.

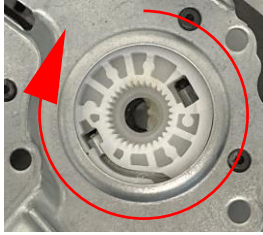
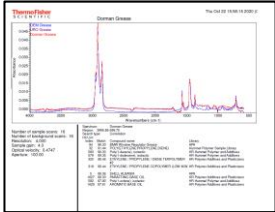
OE Assembly Components:	Picture	OE	URO	BRAND X
Frame	 OEM	Steel Stamped Frame Painted Black	OK	OK
Mounting Studs	 OEM	5x M6-1.0 x 10mm	5x M6-1.0 x 10mm	5x M6-1.0 x 10mm
Window Motor Mounting Plate & Drive Gear	 OEM	Reference	OK	OK
Cable Material	 OEM	Fe with Zn Coating	Fe with Zn Coating	Fe with Zn Coating
Cable Tension	 OEM	7.5N @ $\Delta=0$ mm 23N @ $\Delta=10$ mm	7N @ $\Delta=0$ mm 18.5N @ $\Delta=10$ mm	<b>3.5N @ <math>\Delta=0</math>mm</b> <b>12N @ <math>\Delta=10</math>mm</b>
Cable Abrasion Sleeves	 OEM	2 sleeves	OK	OK

### Component Review Table (continued):

The URO part and the BRAND X Part have the same components as the OE.

OE Assembly Components:	Picture	OE	URO	BRAND X
Pulleys		Plastic Pulley with Grease	<b>Upgraded Pulley with integrated Ball Bearing</b>	Plastic Pulley with Grease
Grease		Grease on drive gear and pulley pins	Grease applied to friction points between the cable and other components including: the frame, drive gear, sliders, pulleys and cable guides.	Grease applied to friction points between the cable and other components including: the frame, drive gear, sliders, pulleys and cable guides.
Sliders		OEM	Reference	<b>Additional Standoff on back of slider prevents full stroke of window glass travel.</b>
Slider Bump Stop		Reference	Reference	OK
Spline ID	 <p>Too large an opening will not provide proper tooth engagement</p>	18.46mm Test Fit with Window Motor OK	18.40mm Test Fit with Window Motor OK	18.9mm Test Fit with Window Motor OK

### Other Testing:

OE Assembly Components:	Picture	OEM	URO	BRAND X
Torque Test (Force required to move the slider from rest.)	 <p>OEM</p>	20 in*lbf	<b>19 in*lbf</b>  <b>(Due to ball bearing pulley.)</b>	<b>15 in*lbf</b>  <b>(Due to low cable tension.)</b>
Grease Material		Reference	96% match	96% match