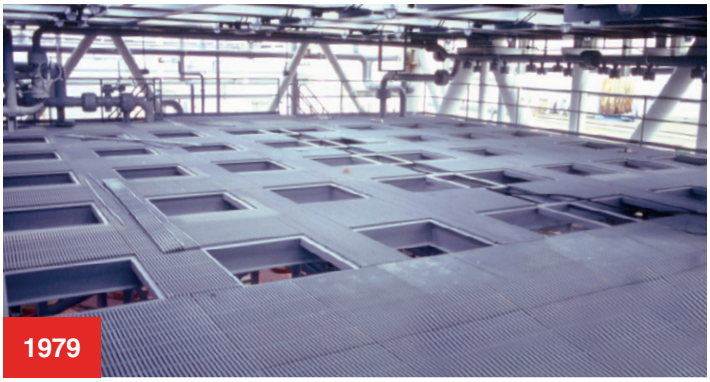
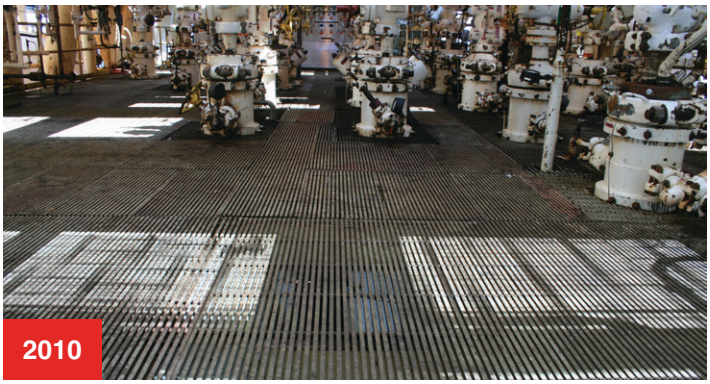
STRONGWELL

DURABILITY STUDY





DECADES LATER: STILL BETTER THAN NEW STEEL

In 1979, over 10,000 square feet of DURAGRID® I-4000 1" (formerly DURADEK®) pultruded grating was installed in lieu of steel grating in the well bays and adjacent areas on Shell's offshore platform Ellen. The platform was destined for the Beta Field off the shore of southern California. Now, with over 40 years of use, the grating continues to show an excellent return on investment for current operators, Beta Offshore.

Anti-skid DURAGRID® has always been known for excellent durability and the 40-plus year exposure on Ellen has had little to no effect on the grating. Even accidental sandblasting and paint overspray has not noticeably degraded the grating's performance.

Previous reports indicated that abuse from the platform's SSV's (surface safety valves) and performing acid jobs have never been a problem. Workers experience less fatigue and a better kneeling environment with DURAGRID® pultruded grating.

When asked in 2010 about the lifespan of the grating on the platform, the Facility Superintendent at that time stated, "The grating looks to be in great shape. The surface shows very little wear and tear."

In 2020, Strongwell was able to acquire and examine a portion of the original grating for flexural testing. The removed panels were taken from an area on the offshore rig that received heavy daily foot traffic and constant UV exposure. Upon visual inspection, the grating had some cosmetic wear with no visual signs of glass exposure.

Span, L=42"		DURAGRID® I-4000 1" Grating		New Steel Grating†	
		Original Published Properties	Properties After 40 Years of Offshore Service	1.5"	1"
Modulus, E		4.88 x 10^6 psi	4.0 x 10^6 psi	29 x 10^6 psi	
Max Load	10 bar panels	4,122 lb*	3,385 lb	1,218 lb	541 lb
	9 bar panels	3,710 lb*	2,901 lb		
Allowable Load		1413 psf	1132 psf	696 psf	309 psf

*Prorated value - I-4000 series has 12 bars per foot of width.
†From ANSI/NAAMM Metal Bar Grating Manual MBG 531-17.

As one of the first generation designs, the panels were assembled with 3/8" FRP rods and polypropylene bushings to achieve proper bar spacing. Today's designs utilize a 3-piece mechanically locked and bonded cross rod design to achieve optimal bearing bar support with peak performance.

With over 40 years of daily exposure to weather and pedestrian traffic, the grating still retained over 80% of its flexural modulus and 80% of its maximum load capability from its published load tables. As tested against the published data for that particular series of grating, the extracted sample maxed out at 3,385 lbs.

Too often, the industry concentrates on short term costs. Now, decades later, the decision to go with DURAGRID® has proven to be a better return on investment than even new steel. ●

TECHNICAL DATA

Product:	FRP Well Bay Platform
Process:	Pultrusion
Materials & Sizes:	DURAGRID® Pultruded Grating and Stairtreads: - I-4000 1"
For:	Ellen Offshore Platform
User:	Beta Offshore (Previously: Aera Energy LLC (formerly Shell Oil Co.))

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STRONGWELL
Chatfield Location

Offshore Grating Panel Property Retention

DATE: 02/06/2020 REPORT #CHA0160

Strongwell performed flexural tests to failure on four grating panels removed from the Ellen offshore platform. These panels were installed on the Ellen offshore platform in 1979 and were provided by the current owner, Amplify Energy. Located directly outside the galley, they have been subjected to more than 40 years of constant environmental exposure and pedestrian wear. Visual inspection shows no grit remaining and no exposed glass.

These panels were assembled with 3/8"∅ FRP rods and polypropylene bushings to provide proper bearing bar spacing. (This was our original pultruded grating assembly method, begun in the late 1970's.) Sample panels were ripped down to accommodate the test fixture width. End bars were pinned at cross rods to prevent panel from disassembling during handling.

The attached load table from August 1985 brochure is applicable to this manufacturing period.

Grating Description: I4000-1", Gray with cross rods at 12", drip edge on bearing bar flanges. Riveted plate states "*DURADEK*® AFC, Inc. Chatfield, MN".

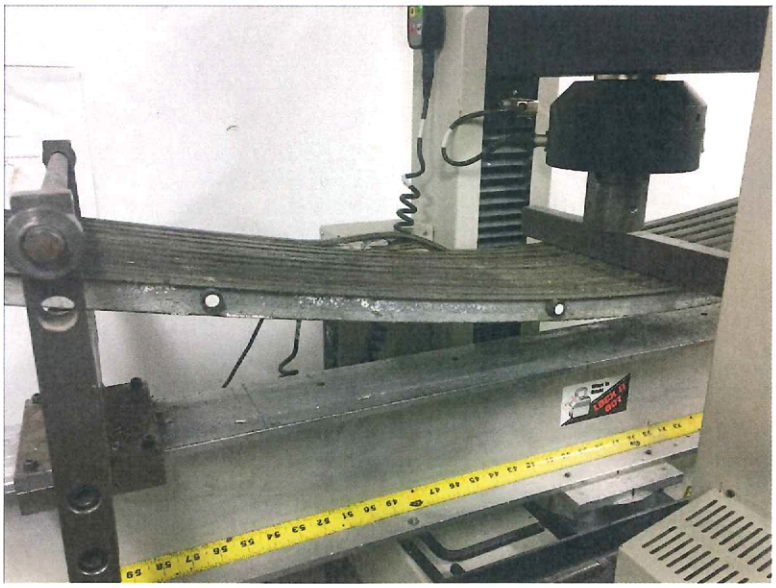
Test Span: 42" with load head centered between cross rods Test Speed: 0.50 inch/minute

Load Table Modulus: 4.88×10^6 psi Average Test Modulus: 4.0×10^6 psi

Adjusted Load Table Maximum Load: (4,947 lb) (10 bars / 12 bars) = 4,122 lb
Average Test Peak Load for 10 bar panels: 3,385 lb

Adjusted Load Table Maximum Load: (4,947 lb) (9 bars / 12 bars) = 3,710 lb
Average Test Peak Load for 9 bar panels: 2,901 lb

Rod-and-bushing cross rods were loose and allowed the bearing bars twist out of vertical plane, resulting in a peak load lower than anticipated. Current 3-piece cross rod improves bearing bar stability and increases peak performance.



CONCLUSION:
After forty years of continuous service and exposure, the grating panels have retained approximately 82% of their flexural modulus and 80% of the maximum load reported in the historic load table.

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

GREGORY R. BOND
02/24/2020
DATE REG. NO. 40306

TEST OBSERVERS:
Gregory Bond, PE
Kealon Vrieze
Jeff Finley

I-4000 1" I Bearing Bars Spaced 1" On Center

OTHER COMMON SERIES AND SPACING (X) :

SERIES	(X)
I-7000	2.000"
I-7500	2.400"
I-8000	3.000"

OR MULTIPLES OF ABOVE

1" I BEARING BARS: VALUES FOR12 BARS PER FT OF WIDTH

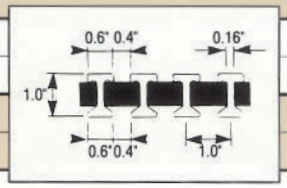
A = 3.744 IN^2/FT OF WIDTH S = 0.984 IN^3/FT OF WIDTH

I = 0.492 IN^4/FT OF WIDTH [3]

WEIGHT/FOOT = ..253 LBS/FT OF BAR

WEIGHT/FOOT = .302 LBS/FT OF CROSS ROD

SPAN INCHES																			MAXIMUM LOAD	SAFE LOAD 2:1 SAFETY FACTOR	E x 10^6 PSI
12	u	200	400	600	800	1000	1500	2000	2500	3000	4000	5000	6000	7000	8000	9000	10000	11000	31200	15600	3.78
	Δu	.002	.005	.007	.010	.012	.018	.024	.030	.036	.048	.060	.073	.085	.097	.109	.121	.133	.377	.188	
	c	100	200	300	400	500	750	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	5500	15600	7800	
	Δc	.002	.004	.006	.008	.010	.015	.019	.024	.029	.039	.048	.058	.068	.078	.087	.097	.107	.303	.151	
18	u	133	267	400	533	667	1000	1333	1667	2000	2667	3333	4000	4667	5333	6000	6667	7333	14862	7431	4.15
	Δu	.007	.015	.022	.030	.037	.056	.074	.093	.111	.149	.186	.223	.260	.297	.334	.371	.408	.828	.414	
	c	100	200	300	400	500	750	1000	1250	1500	2000	2500	3000	3500	4000	4500	5000	5500	11145	5572	
	Δc	.006	.012	.018	.024	.030	.045	.059	.074	.089	.119	.149	.178	.208	.238	.268	.297	.327	.663	.331	
24	u	100	200	300	400	500	750	1000	1250	1500	2000	2500	3000	3500	4000				8700	4350	4.41
	Δu	.017	.033	.050	.066	.083	.124	.165	.207	.248	.331	.414	.496	.579	.662				1.439	.719	
	c	100	200	300	400	500	750	1000	1250	1500	2000	2500	3000	3500	4000				8700	4350	
	Δc	.013	.026	.040	.053	.066	.099	.132	.165	.199	.265	.331	.397	.463	.530				1.152	.576	
30	u	80	160	240	320	400	600	800	1000	1200	1600	2000	2400						5568	2784	4.63
	Δu	.031	.062	.092	.123	.154	.231	.308	.385	.462	.616	.770	.924						2.143	1.071	
	c	100	200	300	400	500	750	1000	1250	1500	2000	2500	3000						6960	3480	
	Δc	.025	.049	.074	.099	.123	.185	.246	.308	.370	.493	.616	.739						1.714	.857	
36	u	67	133	200	267	333	500	667	833	1000	1333								3866	1933	4.83
	Δu	.051	.102	.153	.204	.255	.383	.511	.638	.766	1.021								2.961	1.480	
	c	100	200	300	400	500	750	1000	1250	1500	2000								5799	2899	
	Δc	.041	.082	.123	.163	.204	.306	.408	.510	.613	.817								2.368	1.184	
42	u	57	114	171	229	286	429	571	714										2827	1413	4.88
	Δu	.080	.160	.240	.322	.402	.602	.802	1.002										3.967	1.983	
	c	100	200	300	400	500	750	1000	1250										4947	2473	
	Δc	.064	.128	.193	.257	.321	.481	.642	.802										3.174	1.587	
48	u	50	100	150	200	250	375	500											2155	1077	4.98
	Δu	.117	.235	.352	.470	.587	.881	1.174											5.059	2.530	
	c	100	200	300	400	500	750	1000											4310	2155	
	Δc	.094	.188	.282	.376	.470	.705	.940											4.051	2.025	
54	u	44	89	133	178	222	267												1699	849	5.00
	Δu	.165	.333	.498	.667	.832	1.000												6.363	3.181	
	c	100	200	300	400	500	750												3822	1911	
	Δc	.133	.266	.399	.532	.665	.998												5.083	2.542	



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ISO 9001 Quality Certified Manufacturing Plants

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