

CRYOGENIC EXPANSION JOINT

BELLOWS EXPERTS



www.sjmflex.com



Since its foundation in 1975, **SJM** has been recognized as the one of the world's leading manufacturers of high quality metal and non-metal expansion joints.

SJM is the market share NO.1 expansion joint company for LNG carriers in the world.

ISO 9001 QUALITY MANAGEMENT SYSTEM

SJM's Quality Assurance System has been certified by ISO9001 & ASME section VIII (U1, U2 stamp) and in compliance with ASME B31.1, B31.3, AWS B1.1, AISI and AISC.

TYPE APPROVAL CERTIFICATION

DNV-GL, BV, LR, KR, NK and ABS (Classification Societies)

- X-ray 300KV MA and 5MA Magnetic Particle
- Ultrasonic and Eddy Current Test
- Dye Penetrant
- Helium and Halogen Leak Detection
- Pneumatic Test
- Hydro Test
- Min. Temperature Pressure test for **New IGC Code (Ch.5.13.1.2.2)**
- Cycle Fatigue test (Thermal / Mechanical)
- Burst test
- Spring rate test



ABS



KR



BV



DNV-GL



LR



NK

LNG CARRIER

MEMBRANE TYPE LNG CARRIER
GLOBAL MARKET SHARE NO.1 SJM



FLNG (*FPSO, FSRU)

SHELL PRELUDE FLNG
THE BIGGEST SHIP IN THE WORLD
WORLD FIRST SUPPLIER SJM



LNG BUNKERING LNG VAPORIZER (FSRU) LPG CARRIER



LNG TERMINAL VACUUM INSULATED PIPING



COMPANY PROFILE

- 1975** Sung Jin Machineries founded
Korea first manufacturer of bellows product
- 1985** **Beginning of the production of Marine expansion joint**
Certified by LR, ABS, BV and DNV-GL
- 1989** Beginning of the production of automobile flexible coupling
- 1991** Establish Malaysian joint venture in Klang
- 1996** Rename from Sung Jin Machineries to SJM Co., Ltd.
- 1997** Float on the Korean stock market
KOSPI : SJM123700
- 1997** Establish German & South African Incorporation
- 2001** Establish U.S Incorporation in Ann Arbor
- 2002** Korea first manufacturer of cryogenic bellows for LNG carrier
- 2004** Awarded 20 million USD export prize (KITA)
- 2006** Establish China Incorporation in China
- 2010** Establish Holding Company (SJM Holdings)

LNG BUSINESS HISTORY

RESEARCH & DEVELOPMENT

- 2002** Invention & Localization of LNG Expansion joint
(Certified by LR, ABS, BV, and DNV-GL)
- 2017** **Cryogenic pressure test by New IGC Code**
(Certified by LR, ABS, BV, and DNV-GL)

LNG BUSINESS EXPANSION

- 2005** **Daewoo ship bldg. & marine engineering Co.,Ltd.**
First LNG Carrier supplied - H/N 2233 (TMT)
(2005~2018 : Total 46 LNG Carriers)
- 2006** **Hyundai heavy / Samho heavy industries Co.,Ltd.**
First ship - H/N 1777/78/79/80 (BP)
(2006~2018 : Total 25 LNG Carriers)
- 2007** **Samsung heavy industries Co.,Ltd.**
First ship - H/N 1605/1606 (QG-II)
(2007~2018 : Total 67 LNG Carriers)
- 2012** **Hudong – Zhongha shipbuilding Co.,Ltd.**
First ship - H/N1670A~73A (MOL/EXXON MOBIL)
(2012~2018 : Total 12 LNG Carriers)
- 2016** **Imabari shipbuilding – Saijo**
First ship - H/N 8177/88 (ELCANO)
(2016~2018 : Total 2 LNG Carriers)

PERFORMANCE ACHIEVED

- 2009** 50 Ships supplied
- 2013** 100 Ships supplied
- 2017** 150 Ships supplied

AWARDED (**OUTSTANDING PARTNERS**)

- 2011** Daewoo ship bldg. & marine engineering Co.,Ltd.
- 2013** Samsung heavy industries Co.,Ltd.

* FPSO : Floating, Production, Storage and Offloading
* FSRU : Floating, Storage, Re-gasification Unit



SINGLE



UNIVERSAL



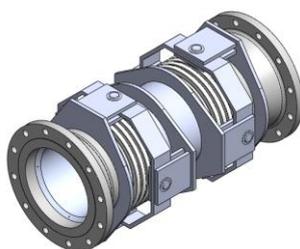
SINGLE



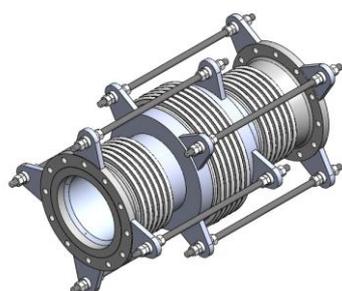
UNIVERSAL



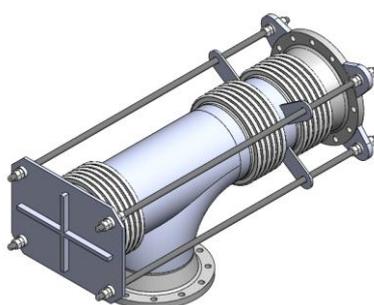
DOUBLE HINGED



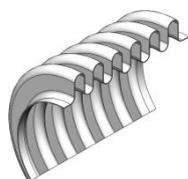
DOUBLE GIMBAL



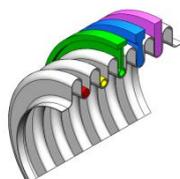
IN-LINE BALANCED



L-BALANCED
(ELBOW)



UN-REINFORCED



REINFORCED

UN-TIED TYPE

The main use of single expansion joint in a piping system is to absorb axial & small amount of lateral & angular movements in which it is installed.

When lateral movements are too excessive for a single axial expansion joint to accommodate or when there is a limitation on the amount of lateral forces allowed on the connecting piping or equipment, universal expansion joints are installed to accommodate these movements.

TIED TYPE

Tied expansion joints consist of one or two bellows with a central pipe and tie rods to withstand reaction forces produced by internal pressure. The universal tied expansion joint allows large lateral movement in all planes, this movement can be increased by increasing the length of the central pipe.

HINGED AND GIMBAL TYPE

Double hinged expansion joints consist of two bellows with pipe ends or flanges. This type of expansion joint come with a central pipe and double hinges to absorb pressure loads created by internal pressure – hence the pipeline does not require strong anchors. Double hinged expansion joints can only accept angular and lateral movements in one plane.

Gimbal expansion joints can absorb angular movements in multiple planes. The benefit of having a gimbal expansion joint is that it absorbs pressure thrust as well as torsional twist. This type of expansion joint consists of 4 hinge restraints that are welded to a flange with one common gimbal pin in the middle. These type of expansion joints are often used in a pair to absorb moments in multiple planes.

BALANCED TYPE

In-line pressure expansion joints are also designed to absorb axial and lateral movements. They are often used on turbines, pumps or compressors. The in-line pressure joint has balancing bellows and line bellows. Balancing bellows are always twice the effective area of in-line bellows and are joined together through a series of tie-rods.

Elbow pressure balanced expansion joints are designed to absorb axial and lateral movements. These kind of expansion joints are used where there is limitation for the main anchors. Pressure thrust force acting on the (middle) bellow is equalized by balancing bellows on either end through a set of tie rods.

REINFORCEMENT

Equalizing ring reinforced expansion joints are a good solution for solving the challenges posed by applications exposed to high pressures.

INCOLOY alloy 825

INCOLOY alloy 825 (UNS N08825) is an austenitic nickel-iron-chromium alloy with additions of molybdenum and copper. It has excellent resistance to both reducing and oxidizing acids, to stress corrosion cracking, and to localized attacks such as pitting and crevice corrosion. Alloy 825 is especially resistant to sulfuric and phosphoric acids. It offers outstanding performance in seawater.

INCOLOY alloy 825 has good impact strength at room temperature and retains its strength at cryogenic temperatures.

The outstanding attribute of INCOLOY alloy 825 is its high level of corrosion resistance. In both reducing and oxidize environments, the alloy resists general corrosion, pitting, crevice corrosion, intergranular corrosion, and stress corrosion cracking. Some environments in which INCOLOY alloy 825 is particularly useful are sulfuric acid, phosphoric acid, sulfur-containing flue gases, sour gas and oil wells, and sea water.

Form and Condition	Tensile Strength		Yield Strength (0.2% Offset)		Elongation, %
	ksi	MPa	ksi	MPa	
Tubing, Annealed	112	772	64	441	36
Tubing, Cold Drawn	145	1000	129	889	15
Bar, Annealed	100	690	47	324	45
Plate, Annealed	96	662	49	338	45
Sheet, Annealed	110	758	61	421	39

Nominal room-temperature Mechanical Properties

Temperature		Orientation	Impact Strength ^a	
°F	°C		ft-lb	J
Room	Room	Longitudinal	79.0	107
		Transverse	83.0	113
-110	-43	Longitudinal	78.0	106
		Transverse	78.5	106
-320	-196	Longitudinal	67.0	91
		Transverse	71.5	97
-423	-253	Longitudinal	68.0	92
		Transverse	68.0	92

Low-temperature impact strength of plate

INCONEL alloy 625

INCONEL alloy 625 (UNS N06625) is a nickel-chromium-molybdenum alloy possessing excellent resistance to oxidation and corrosion over a broad range of corrosive conditions, including aerospace and chemical process applications. The alloy has outstanding strength and toughness at temperatures ranging from cryogenic to elevated temperatures in the range of 2000°F(1093°C). Alloy 625 also has exceptional fatigue resistance.

The high alloy content of INCONEL alloy 625 enables it to withstand a wide variety of severe corrosive environments. In mild environments such as the atmosphere, fresh and sea water, neutral salts, and alkaline media there is almost no attack.

INCONEL alloy 625 retains its excellent ductility and toughness at low temperature.

Form and Condition	Tensile Strength, ksi	Yield Strength (0.2% Offset), ksi	Elongation, %	Reduction of Area, %	Hardness, Brinell
ROD, BAR, PLATE					
As-Rolled	120-160	60-110	60-30	60-40	175-240
Annealed	120-150	60-95	60-30	60-40	145-220
Solution-Treated	105-130	42-60	65-40	90-60	116-194
SHEET AND STRIP					
Annealed	120-150	60-90	55-30	-	145-240
TUBE AND PIPE, COLD-DRAWN					
Annealed	120-140	60-75	55-30	-	-
Solution-Treated	100-120	40-60	60-40	-	-

Nominal room-temperature Mechanical Properties

Test Temp., °F	Orientation	Impact Strength, ft-lb
85	Longitudinal	48, 49, 50
	Transverse	46, 49, 51.5
-110	Longitudinal	39, 44, 49
	Transverse	39, 42, 44
-320	Longitudinal	35, 35, 35.5
	Transverse	31, 32, 36

Low-temperature impact strength of plate

TYPE 316L Stainless steel

Type 316L stainless steel is an extra-low carbon version of the 316 steel alloy. The lower carbon content in 316L minimizes deleterious carbide precipitation as a result of welding. Consequently, 316L is used when welding is required in order to ensure maximum corrosion resistance.

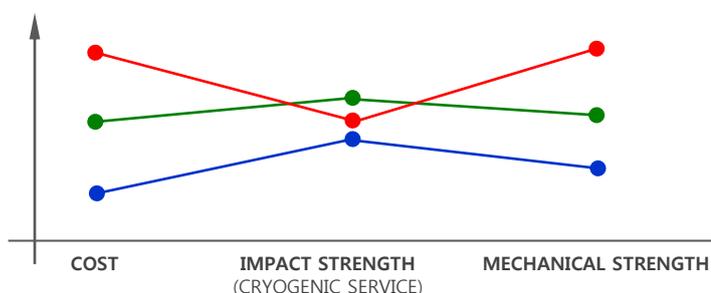
The austenitic structure also gives these grades excellent toughness, even down to cryogenic temperatures.

Compared to chromium-nickel austenitic stainless steels, 316L stainless steel offers higher creep, stress to rupture and tensile strength at elevated temperatures.

Tensile Strength (MPa) min	Yield Strength 0.2% Proof (MPa) min	Elongation (% in 50mm) min	Hardness	
			Rockwell B (HR B) max	Brinell (HB) max
485	170	40	95	217

Mechanical Properties

COMPARISON OF 316L, INCONEL 625 AND INCOLOY 825



Inconel 625	—
Incoloy 825	—
Type 316L	—

General application of bellows material

Inner ply : Type 316L

Outer ply : Type 316L or Inconel 625 or Incoloy 825

BELLOWS DESIGN

DESIGN CODE & STANDARDS

EJMA (Expansion Joint Manufacturers Association)
 IGC (International Code for the Construction and Equipment of ships)
 KR, ABS, BV, LR and DNVGL (Classification Society Rules)

DESIGN CONDITION

PRESSURE : 1 ~ 35 BarG
 TEMPERATURE : -196 ~ 200 °C

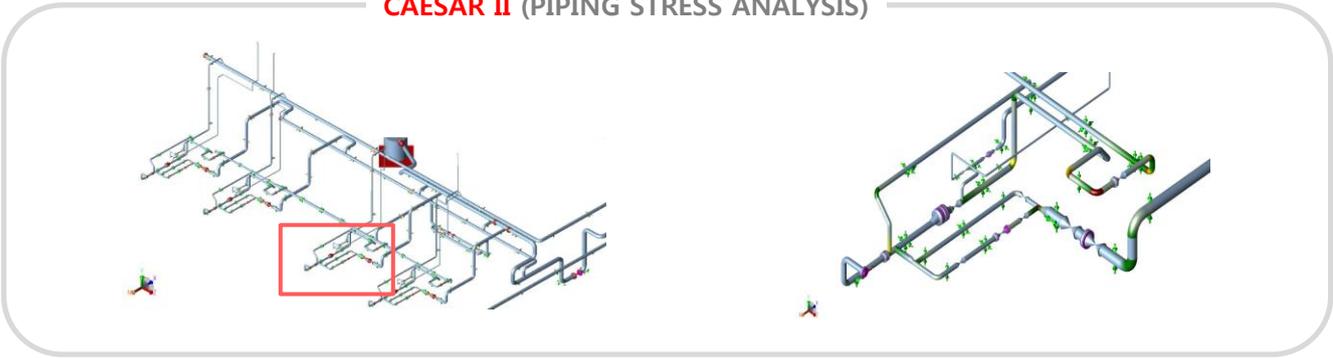
BELLOWS MATERIAL (HYDRAULIC FORMING)

STAINLESS STEEL TYPE 316L
 INCONEL ALLOY 625 / INCOLOY ALLOY 825

ANALYSIS EVALUATION

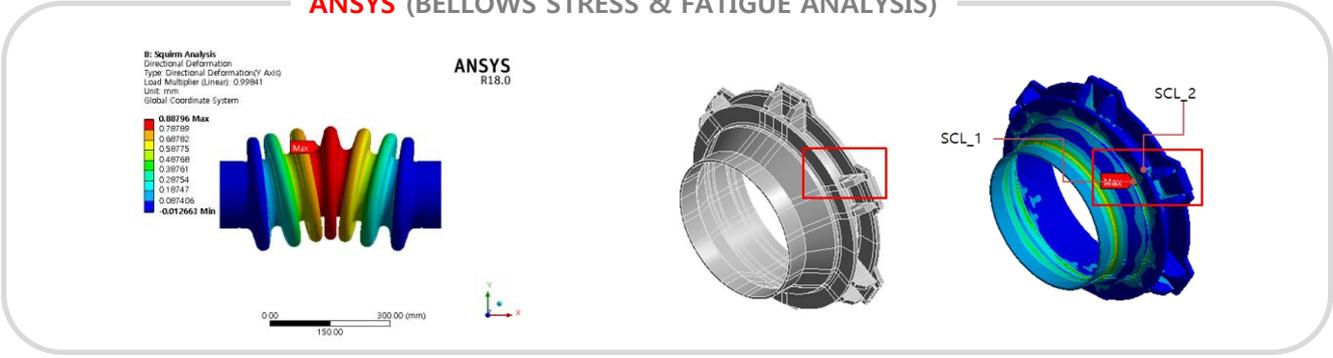
CAESAR II evaluates the structural responses and stresses of piping systems to international codes and standards.

CAESAR II (PIPING STRESS ANALYSIS)



ANSYS evaluates the structural stresses and fatigue cycle of bellows element. In addition, structural stability for pipes and other pressure parts can be evaluated to qualify bellows normal operation.

ANSYS (BELLOWS STRESS & FATIGUE ANALYSIS)



CLASSIFICATION TYPE APPROVAL TEST

Expansion bellows should be required to perform the Type approval test in accordance with IGC Code. SJM has been approved by the classification societies to meet the cryogenic pressure test requirements of the **New IGC Code**.

BURST TEST

CYCLE TEST

CRYOGENIC TEST



LNG CARRIERS (281 SHIPS)

DAEWOO SHIPBUILDING & MARINE ENGINEERING CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
TMT	H2233	1	DNVGL	2005
KNUTSEN	H2236	1	DNVGL	2005
TEEKAY	H2238/2239/2240	3	LR	2006
QG-II (PRONAV)	H2245/2246/2247/2248	4	LR	2006~2007
RAS GAS III	H2249/2250/2251/2252/2253	5	ABS	2007
KOGAS	H2260/2261	2	KR/BV	2007
SOVCOMFLOT	H2241/2242	2	DNVGL	2007~2008
KNUTSEN	H2267/2269/2274/2275	4	DNVGL	2009~2010
SOMANGOL	H2280/2281/2282	3	ABS	2010~2011
TEEKAY	H2407/2408/2411/2416/2417	5	DNVGL	2014~2016
KOGAS	H2449/2450/2451/2452	4	KR/ABS	2016~2017
TEEKAY	H2453/2454/2455/2461	4	DNVGL	2017~2018
CHANDRIS	H2460/2464	2	ABS	2017~2018
BP	H2441/2442/2443/2444/2445/2446	6	LR	2017~2019
		46		

SAMSUNG HEAVY INDUSTRIES CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
QG-II (OSG)	S1605/1606	2	DNVGL	2007
RAS GAS III	S1643/1644/1645/1646	4	DNVGL	2007~2008
CVX	S1641/1642	2	ABS	2009
QGTG	S1675/1676/1677/1694/1695/1697	6	LR	2008
ILTC	S1686	1	ABS	2009
QGTG	S1696	1	ABS	2009
LEIF HOEGH	S1688/1689	2	DNVGL	2009
QGTG	S1726/1751/1752/1753/1754	5	ABS	2009
ANGOLA	S1810/1811/1812/1813	4	ABS	2010~2011
GAS LOG	S1946/1947/2016/2017	8	ABS	2013~2014
	S2041/2042/2043/2044			
CHEVRON	S1920/1921/1941/1942/2069/2070	6	ABS	2014~2015
GOLAR	S2021/2022/2023/2026/2027	9	DNVGL	2012~2014
	S2047/2048/2055/2056			
THENAMARIS	S2045/2046/2049	3	DNVGL	2013~2014
BGT	S2076/2077/2078/2079	4	ABS	2015~2016
FLEX TANK	S2107/2108	2	ABS	2015~2016
SK	S2080/2081	2	BV	2016~2017
KOGAS	S2153/2154	2	KR/ABS	2016~2017
MBK	S2148/2149/2150	3	ABS	2017~2018
GAS LOG	S2212/2213/2262/2274	4	ABS	2018~2019
CARDIFF	S2271/2275/2276/2308	4	ABS	2019~2021
CELSIUS TANKERS	S2297/2298/2313/2314	4	LR	2020~2021
GAS LOG	S2300/2301/2311/2312	4	ABS	2020~2021
NYK	S2302/2306/2307/2355	4	ABS	2020~2021
MINERVA MARINE	S2304/2305/2332	3	ABS	2020~2021
NAVIGARE	S2310	1	DNVGL	2021
MERIDIAN	S2336/2337	2	ABS	2021
NISSHIN	S2319	1	BV	2021
SINOKOR	S2315	1	BV	2021~2022
MISC	S2364/2365	2	ABS	2022~2023
PAN OCEAN	S2426	1	ABS	2022
MARAN	S2425/2473/2474	3	BV	2022~2023
PAN OCEAN	S2580/2581/2582/2583	4	DNVGL	2022~2024
CELSIUS TANKERS	S2459~61/2579/2584/2585/2598/2599	8	LR	2023~2025
		112		

IMABARI SHIPBUILDING SAJO (JAPAN)				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
ELCANO	H8177/8188	2	LR	2016
		2		

LNG FPSO (4 SHIPS)

SAMSUNG HEAVY INDUSTRIES CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
SHELL	H2030 (PRELUDE)	1	LR	2013~2014
PETRONAS	H2126	1	ABS	2013~2014
ENI	H2235	1	LR	2018
		3		

LNG FSRU (12 SHIPS)

SAMSUNG HEAVY INDUSTRIES CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
GOLAR	H2024/2031/2189	3	DNVGL	2013~2016
BW Maritime	H2074/2118	2	DNVGL	2014~2015
HOEGH	H2220	1	DNVGL	2018
JAWA	H2255	1	BV	2020
		7		

HYUNDAI HEAVY INDUSTRIES CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
SWAN	H2993	1	LR	2019
		1		

GAS ENTEC CO., LTD. & DONGHWA ENTEC CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
PAXOCEAN	26K FSRU	1	LR	2018
GAS LOG	1062 (VAPORIZER)	1	DNVGL	2017
		2		

HUDONG - ZHONGHA SHIPBUILDING (GROUP) CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
DYNAGAS	H1786A/1787A	2	ABS	2019
		2		

LNG DUAL FUELD (19 SHIPS)

HYUNDAI SAMHO HEAVY INDUSTRIES CO.,LTD.				
SHIP	Hull NO.	Q'TY	CLASS	DELIVERY
CONTAINER CARRIER	S990/991/992/993/994/995	6	LR, DNVGL	2019~2021
BULK CARRIER	S8034/8035/8037/8038	4	KR, DNVGL	2020~2021
BULK CARRIER	S8120/8121	2	KR	2022
CONTAINER CARRIER	S8150/8151	2	KR	2022
		14		

HYUNDAI HEAVY INDUSTRIES CO.,LTD.				
SHIP	Hull NO.	Q'TY	CLASS	DELIVERY
CONTAINER CARRIER	H3162~66/3178~83, 3264~67	15	LR, DNVGL	2020~2023
CONTAINER CARRIER	H3274/3275	2	ABS	2022~2023
		17		

HYUNDAI HEAVY INDUSTRIES CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
BP	H1777/1778/1779/1780	4	LR	2006~2008
QG-II (OSG)	H1791/1792	2	DNVGL	2007
RAS GAS III	H1862/1863/1875	3	DNVGL	2007~2008
QGTG	H1908/1909/1910	3	DNVGL	2008
BGT	H2636/2637	2	LR	2015
PETRONET	H2633	1	BV	2016
SK E&S	H2937/2938	2	KR, ABS	2018
CARDIFF	H3020/3021/3022	3	BV, ABS	2019~2020
THENAMARIS	H3096/3126	2	ABS	2020
CAPITAL GAS	H3105/3106/3107/3108/3109/3110/3011	7	BV, LR	2020~2022
CARDIFF	H3037/3038/3039/3112	4	ABS	2020~2021
SK E&S	H2939/3145	2	KR, ABS	2021~2022
TSAKOS	H3157	1	DNVGL, BV	2021
SHELL	H3185/3186/3187/3188~91/3198	8	DNVGL, LR	2021~2023
SHELL	H3221~25, 3320/21	7	DNVGL, KR	2022~2024
CAPITAL GAS	H3315/3316/3341/3342	4	ABS	2022~2024
DYNAGAS	H3290/3291/3292/3293	4	BV	2022~2024
HYUNDAI LNG SHIP	H3294~99	6	DNVGL, BV	2022~2024
		65		

HYUNDAI SAMHO HEAVY INDUSTRIES CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
BP	S297/298	2	LR	2008
MARAN GAS	S624	1	DNVGL	2013
MARAN GAS	S625/627	2	ABS	2014
MARAN GAS	S626	1	LR	2014
TEEKAY	S856/857	2	DNVGL	2018
SOVCOMFLOT	S8006/8007/8008	3	BV	2018~2019
WHITEBRIDE	S8010/8011/8012/8013	4	DNVGL	2019~2020
NYK	S970/971	2	BV	2019~2021
NYK	S8029/8030/8031/32/33	5	ABS	2020~2021
SHELL	S8091/8092/8093/8094/8095/8096/8100	7	DNVGL, LR	2021~2023
SHELL	S8101/8102	2	DNVGL	2022~2024
SOVCOMFLOT	S8105/8106/8107	3	DNVGL	2022~2024
CAPITAL GAS	S8140	1	ABS	2023
		35		

HANJIN HEAVY INDUSTRIES & CONSTRUCTION CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
KOGAS	N192/193	2	KR/DNVGL	2008~2009
		2		

STX OFFSHORE & SHIPBUILDING CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
ELCANO	S3008	1	BV	2009
		1		

HUDONG - ZHONGHA SHIPBUILDING (GROUP) CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
MOL/EXXON MOBIL	H1670A/1671A/1672A/1673A	4	ABS	2012~2013
MOL/CSC/SINOPEC	H1715A/16A/17A/18A/19A/20A	6	LR	2015~2016
MOL/LNG BUNKERING	H1817A	1	BV	2019
MOL/LNG BUNKERING	H1870A	1	BV	2020
K-LINE	H1788A/89A	2	BV	2021
K-LINE	H1837A/38A	2	ABS, CCS	2021~2022
CSSC	H1829A/30A	2	LR, CCS	2022~2023
		18		

DAEWOO SHIPBUILDING & MARINE ENGINEERING CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
PETRONAS	P6302	1	DNVGL	2014
		1		

LNG TERMINAL (7 PROJECTS)

LNG TERMINALS				
CLIENT	PROJECT NAME	Q'TY	DELIVERY	
KOGAS	Pyung-Taek LNG Terminal	1	1993	
IHI	Tongyoung LNG Terminal	1	2001	
IHI	Incheon LNG Terminal	1	2003	
IHI	Egypt LNG PJT	1	2003	
IHI	India LNG PJT	1	2003	
IHI	USA SABINE LNG PJT	1	2006	
SAMSUNG C&T	Singapor LNG Terminal (S-LNG)	1	2013	
		7		

LPG/ETHANE/METHANOL FPSO (9 SHIPS)

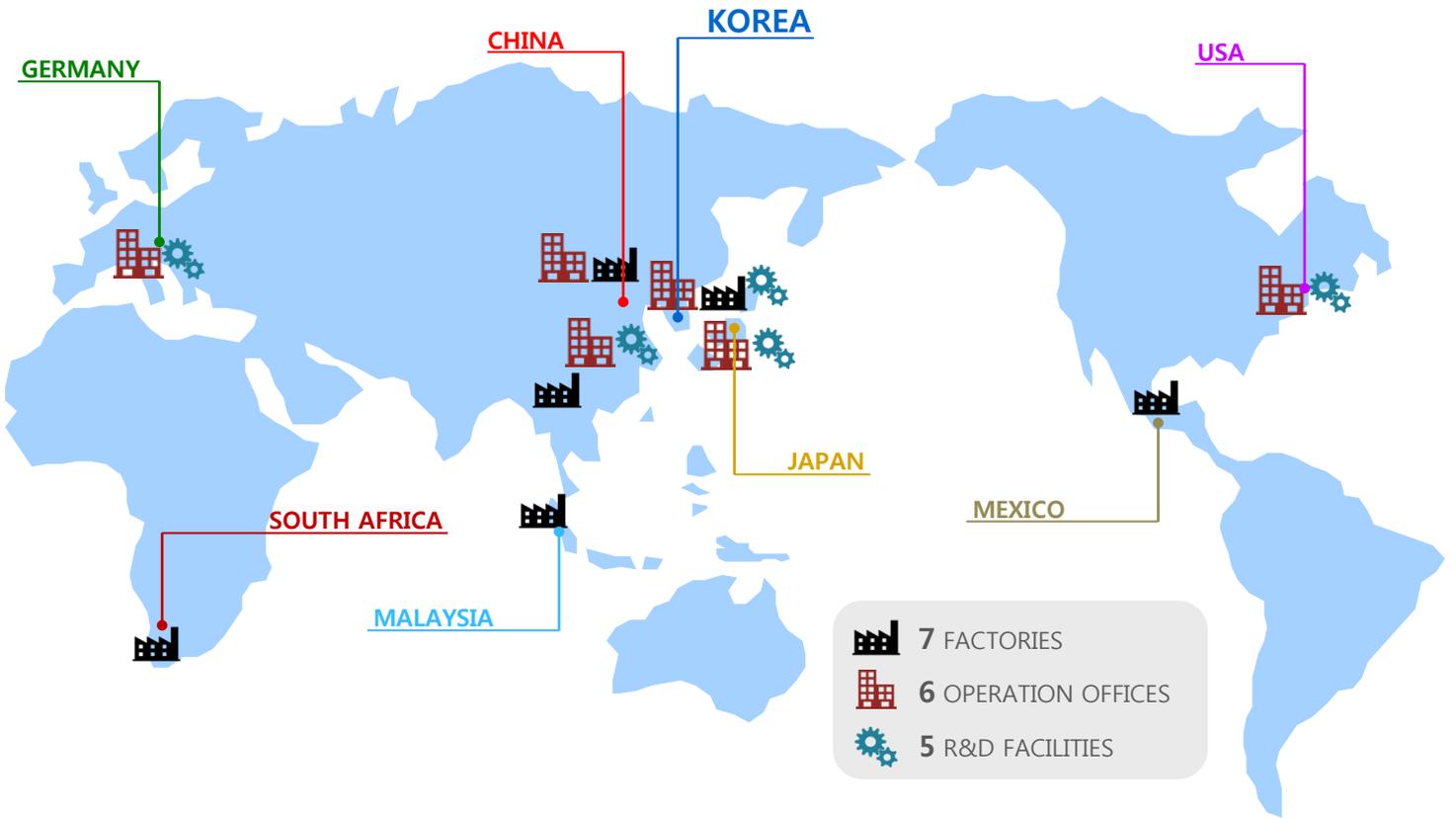
HYUNDAI HEAVY INDUSTRIES CO.,LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
EXXON MOBIL	H1525 (METHANOL FPSO)	1	DNVGL	2003
NEGMAR	H2604/2605 (LPG CARRIERS)	2	ABS	2013
		3		

SAMSUNG HEAVY INDUSTRIES CO., LTD.				
SHIP OWNER	Hull NO.	Q'TY	CLASS	DELIVERY
RELIANCE	S2142/2143/2144/2145/2146/2147 (ETHANE)	6	LR	2019
		6		

SAMSUNG HEAVY INDUSTRIES CO., LTD.				
SHIP	PROJECT / Hull NO.	Q'TY	CLASS	DELIVERY
OIL TANKER	2197, 2198	2	ABS	2018
		2		



GLOBAL NETWORK



CLASS



SHIPYARD



CUSTOMERS



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