ATK Space – Commerce

PMD Heritage Update

Sept 2015

ATK Commerce Overview

An advanced weapon and space systems company

ORGANIZATION

- Founded in 1963
- 120 employees
- Annual sales $40M - $50M
- Niche market player

OPERATIONS

- 104,000 ft^2 facility
- Vertically integrated
  - Design
  - Machine (≥0.017”)
  - Weld
  - Heat treat
  - Cleaning
  - Testing
  - NDI
  - Rubber fabrication
- Many recent upgrades

PRODUCTS

- Light weight pressure vessels
- Propellant tanks
  - Containing Propellant Management Devices (PMD)
  - Containing Diaphragm
  - Other devices or spinners
- Pressurant tank
  - All metal
  - Composite overwrapped pressure vessel (COPV)
- Integrated tank + structure

HERITAGE

- Extensive flight heritage
- Delivered 5,972 tanks to date
- Zero failure
- Over 560 tank designs
- Hundreds of space programs
- Industry leader
- Innovators in tank, PMD, diaphragm, & integrated structure designs

Marketing Level – Non Export Controlled

ATK Commerce Products

An advanced weapon and space systems company

Propellant Tanks with Propellant Management Devices

- Quantity leader, 1,373 delivered to date
- World renowned PMD designer
- Largest # of PMD designs, ≈50

Propellant Tanks with Elastomeric Diaphragms

- Quantity leader, 1,091 delivered to date
- Decades of heritage (Pioneer, Voyager)
- Largest # of diaphragm tank designs

High Pressure COPV

- Titanium-lined COPV
- Highest performance ratio, >1.5 x 10^6 in
- Best overall value
- Sales to U.S., Japan, India, and European countries

Propellant Tanks With Other Internal Devices

- Vortex Suppressor
- Baffles
- Dip Tubes

Motor Cases & Spinners

Star Cases:

- Star 48
- Star 27

Spinners

- Spherical
- Conical

Integrated Tank and Structure

- New revolutionary product line
- Integrated design/manufacturing/test

Marketing Level – Non Export Controlled

ATK Commerce Tank Shells

An advanced weapon and space systems company

All Metal Shells

- Heritage Shells
- Propellant and Pressurant Tanks

Composite Overwrapped Pressure Vessel (COPV)

- Titanium-lined COPV
- Fully wrapped

Hybrid Shells

- All Metal Domes
- Composite Wrapped Cylinder Section
- Propellant tanks

Load Bearing Integrated Shell

- Tank shell completely integrated with composite structure

Marketing Level – Non Export Controlled

Exploration Footprint

An advanced weapon and space systems company

- Earth:
  - GOES
  - Earth Obs Sat
  - Space Station
  - Landsat
  - Radarsat
  - TRMM
  - OCO
  - Cloudsat
  - MMS
  - Many more

- Space Station
- Space Shuttle
- TDRS
- IUS

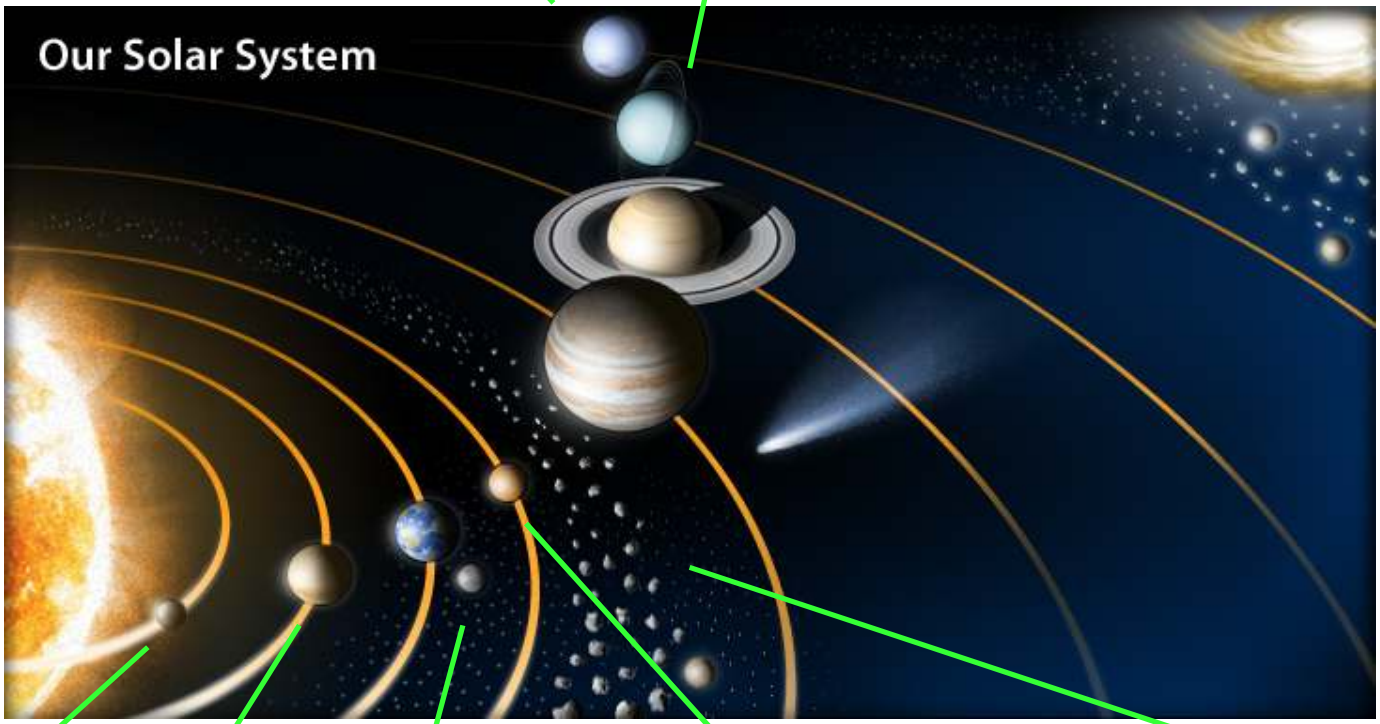
- Neptune
  - Voyager 2

- Uranus
  - Voyager 2

- Pluto
  - New Horizons

- Solar System:
  - Pioneers
  - Voyagers
  - Mariners

- Cosmos
  - Pioneers
  - Voyagers
  - JWST
  - COBE
  - Chandra
  - Gamma Ray Observatory
  - GLAST
  - Kepler
  - Astro F
  - HEAO



- Sun:
  - Ace
  - Genesis
  - Glory
  - Solar-B
  - SOHO
  - SDO
  - STEREO
  - Ulysses

- Comets
  - Deep Impact

- Saturn
  - CASSINI
  - Pioneer 10 & 11
  - Voyagers 1 & 2

- Jupiter
  - CASSINI
  - Pioneer 10 & 11
  - Voyagers 1 & 2

- Mercury:
  - MESSENGER
  - Mariner 10

- Venus:
  - Magellan
  - Pioneer Venus
  - MESSENGER
  - Mariner 10

- Moon:
  - LRO
  - LCROSS
  - Clementine
  - LADEE
  - Grail
  - Lunar Prospector
  - Chandrayaan I & II

- Mars:
  - Mars Science Lab
  - Phoenix
  - Mars Rovers
  - Mars Polar Lander
  - Mars Pathfinder
  - Maven
  - Juno
  - Mariners
  - Mars Recon Orbiter
  - Mars '98
  - Vikings 1 & 2
  - ExoMars

- Asteroids
  - Dawn
  - Deep Space 1
  - NEAR

Marketing Level – Non Export Controlled

Early PMD Tanks

INSAT PMD Tank (80277 & 80283)

- PMD designed by Customer in 1979
- Tank size: 83 cm Ø (33 in Ø)
- Simple center-post, 4-vane PMD
- PSI built 6 tanks + Qual tank

Vane PMD Tank (80281 family)

- PMD designed by Customer in 1979
- Tank size: 56 cm Ø x 81 cm long (22 in Ø x 32 in long)
- Simple center-post, 4-vane PMD
- PSI built 52 tanks, including 2 qual tanks

Marketing Level – Non Export Controlled

Early PMD Tanks

INSAT Auxiliary PMD Tank (80292)

- A "Liner"
- PMD designed by Customer in 1981
- Tank size: 18 cm Ø (7 in Ø)
- Moderately complex liner PMD
- PSI built 3 tanks + Qual tank

ARABSAT PMD Tank (80301)

- PMD designed by Customer in 1981
- Tank size: 86 cm Ø (34 in Ø)
- Complex sponge, trap, and vane PMD
- PSI built 8 tanks + Qual tank

Marketing Level – Non Export Controlled

Early PMD Tanks

INMARSAT II & III PMD Tanks (80334)

- PMD designed by Customer in 1983
- Don participated in PMD design analysis
- Tank size 58: cm Ø x 102 cm long (23 in Ø x 40 in long)
- Complex trap, sponge, and vane PMD
- PSI built 16 tanks + 1 Qual tank

MILSTAR PMD Tank (80324)

- PMD designed by Customer in 1984
- Don Jaekle responsible for PMD design & analysis
- Tank size: 84 cm Ø (33 in Ø)
- Complex trap and gallery arms PMD
- PSI built 14 tanks + Qual tank
- Extensive in-orbit capability

Marketing Level – Non Export Controlled

Early PMD Tanks

GOES PMD Tank (80338)

- PMD designed by Customer in 1986
- Tank size: 102 cm Ø (40 in Ø)
- Moderately complex gallery PMD
- PSI built 10 tanks + Qual tank

S5000 PMD Tank (80339)

- PMD designed by Customer in 1987
- Tank size: 79 cm Ø (31 in Ø)
- Simple trap and vane PMD
- PSI built 16 tanks + Qual tank

Marketing Level – Non Export Controlled

PMD Tanks from 1980's

HS 601 PMD Tank (80350 & 80415)

- PMD designed by PMD Technology in 1988
  - Most popular commercial geosynchronous satellite
  - Hughes's first 3-axis stabilized satellite
- Don Jaekle responsible for PMD design & analysis
- Tank size: 89 cm Ø (35 in Ø)
- Moderately complex trap, sponge, and vane PMD
- PSI built 241 tanks + 1 Qual tank (spherical & extended)
  - Most are flying, many retiring

8482 PMD Tank (80356)

- Designed in 1988
- Don Jaekle responsible for PMD design & analysis
- Simple vane-type PMD
- PSI built 6 tanks + Qual tank

Marketing Level – Non Export Controlled

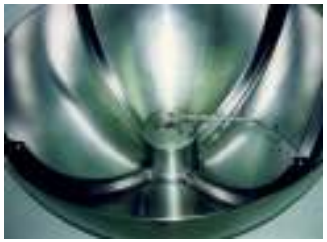
PMD Tanks from 1990's

IntelSat 7A PMD Tank (80363 & 80367)

- PMD designed by Customer in 1991
- Don Jaekle participated in PMD analysis
- Tank size: 124 cm Ø x 152 cm long (49 in Ø x 60 in long)
- Complex trap and gallery PMD
- PSI built 7 tanks + Qual tank

N-Star PMD Tank (80366)

- PMD designed by Customer in 1992
- Don Jaekle participated in PMD design analysis
- Tank size: 124 cm Ø (49 in Ø)
- Same PMD design as I-7A: trap and gallery PMD
- PSI built 6 tanks + Qual tank



Marketing Level – Non Export Controlled

PMD Tanks from 1990's

Iridium PMD Tank (80375)

- PMD designed for Lockheed in 1993
- Don Jaekle responsible for PMD design and analysis
- Tank size: 62 cm Ø x 74 cm long (25 in Ø x 29 in long)
- Simple center-posted vane PMD
- PSI built 99 tanks + Qual tank
  - Over 80 flying

S7000 PMD Tank (80373)

- PMD designed by Customer in 1993
- Don Jaekle participated in PMD analysis
- Tank size: 86 cm Ø (34 in Ø)
- Moderately complex gallery, trap, and vane PMD
- PSI built 36 tanks + Qual tank

Marketing Level – Non Export Controlled

PMD Tanks from 1990's

FS1300 PMD Tank (80380)

- PMD designed for Space Systems/Loral in 1994
- Don Jaekle responsible for PMD design and analysis
- Tank size: 124 cm Ø (49 in Ø)
- Moderately complex trap, sponge and vane PMD
- PSI built 76 tanks + Qual tank
  - At least 48 flying

Chandra IPS PMD

- PMD designed for TRW in 1995
  - NASA's X-ray observatory
  - Designed to be installed through a 15 cm hole
- Don Jaekle responsible for PMD design and analysis
- Moderately complex sponge, baffle and center post PMD
- PSI built 4 flight PMD's + Qual PMD
  - Currently flying

Marketing Level – Non Export Controlled

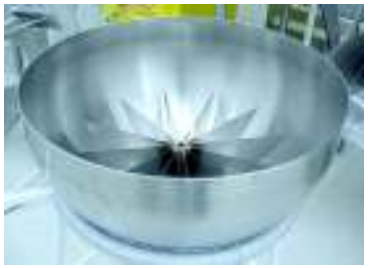
PMD Tanks from 1990's

A2100 Fuel PMD Tank (80391 family)

- PMD designed by Customer in 1995
- Don Jaekle participated in PMD analysis
- Tank size: 89 cm Ø x 277 cm long (35 in Ø x 109 in long)
- Simple sump and vane PMD
- PSI built 32 tanks +1 Qual tank
- This tank is in production

A2100 Oxidizer PMD Tank (80395 family)

- PMD designed by Customer in 1995
- Don Jaekle participated in design analysis
- Tank size: 56 cm Ø x 165 cm long (22 in Ø x 65 in long)
- Simple PMD - 2 versions
  - Sump & vane
  - Vane only
- PSI built 136 tanks + 1 Qual tank
- This tank is in production



Marketing Level – Non Export Controlled

PMD Tanks from 1990's

HS 601 Block II PMD Tank (80399)

- PMD designed for Hughes in 1996
  - Upgraded existing PMD to operate within an extended tank shell
- Don Jaekle responsible for PMD design and analysis
- Tank size 89 cm Ø x 117 cm long (35 in Ø x 46 in long)
- Moderately complex trap, sponge, and vane PMD
- PSI built 22 tanks + Qual tank

Special Mission PMD (80398)

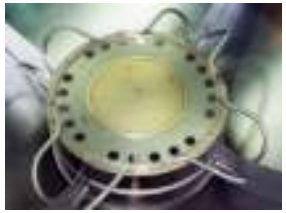
- PMD designed in 1996
- Don Jaekle responsible for PMD design and analysis
- Tank size: 73 cm Ø x 140 cm long (29 in Ø x 55 in long)
- Moderately complex pickup assembly and V-vane PMD
- PSI built 25 tanks + Qual tank
- This tank is in production

Marketing Level – Non Export Controlled

PMD Tanks from 1990's

Extended FS1300 PMD Tank (80403, 80422, 80441, 80442 & family)

- PMD designed for Space Systems/Loral in 1997
  - Upgrade existing PMD to function within an extended tank shell
  - Longer vanes
- Don Jaekle responsible for PMD design and analysis & upgrades
- Tank size: 124 cm Ø x 150 cm long (49 in Ø x 59 in long)
- Moderately complex trap, sponge, and vane PMD
- PSI built 128 tanks + Qual tank



P-81 PMD Tank (80387)

- PMD designed by Customer in 1998
- Tank size: 56 cm Ø x 74 cm long (22 in Ø x 29 in long)
- Simple 8-vane PMD
- PSI built 26 tanks + Qual tank

Marketing Level – Non Export Controlled

PMD Tanks from 1990's

Space Station Interim Control Module 80404)

- PMD designed for Naval Research Laboratory in 1998
  - PMD Installed through two 12.7 cm holes
- Don Jaekle responsible for PMD design and analysis
- Complex gallery PMD
- PSI built 4 PMD's + Qual PMD

BSAT 2 PMD (80420)

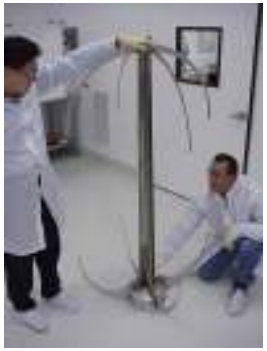
- PMD designed for Orbital Sciences Corporation in 1999
- Don Jaekle responsible for PMD design and analysis
- Tank size: 56 cm Ø x 80 cm long (22 in Ø x 31 in long)
- Simple trough and center-posted vane PMD
- PSI built 6 tanks

Marketing Level – Non Export Controlled

PMD Tanks from 1990's

STAR-2 Fuel Tank PMD (80432)

- PMD designed for Orbital Sciences Corporation in 1999
  - OSC's first 3-axis stabilized, commercial geosynchronous satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 90 cm Ø x 176 cm long (35 in Ø x 69 in long)
- Moderately complex trap and center-posted vane PMD
- PSI built 15 tanks + qual tank



STAR-2 Oxidier Tank PMD (80426)

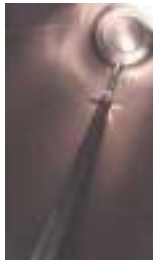
- PMD designed for Orbital Sciences Corporation in 1999
- Don Jaekle responsible for PMD design and analysis
- Tank size: 53 cm Ø x 107 cm long (21 in Ø x 42 in long)
- Moderately complex trough and sponge PMD
- PSI built 32 tanks + Qual tank

Marketing Level – Non Export Controlled

PMD Tanks from 1990's

OrbCom PMD Tank (80421)

- PMD designed for Orbital Sciences Corporation in 1999
- Don Jaekle responsible for PMD design and analysis
- Tank size: 13 cm Ø x 93 cm long (5 in Ø x 24 in long)
- Simple U-vane PMD
- PSI built 10 tanks + Qual tank



Proprietary PMD Tank (P/N 80430)

- PMD designed for MELCO in 1999
  - LEO observatory
- Don Jaekle responsible for the PMD design & analysis
- Tank size 103 cm Ø (40.5 in Ø)
- Simple sponge and vane PMD
  - Not designed for horizontal handling
- PSI/ATK built 11 tanks, including QT
- This tank is still in production
- Also used on NASA GLAST program

Marketing Level – Non Export Controlled

PMD Tank from 2000's

Astrolink Fuel Tank PMD (80434)

- PMD designed for Lockheed Martin in 2000
- Don Jaekle responsible for PMD design and analysis
- Tank size: 89 cm Ø x 340 cm long (35 in Ø x 133 in long)
- Complex trap, sponge, slosh control device and vane PMD
- ATK built 7 tanks to date, in production
- This tank is the longest tank from ATK

A2100 Astrolink Oxidizer Tank (80435)

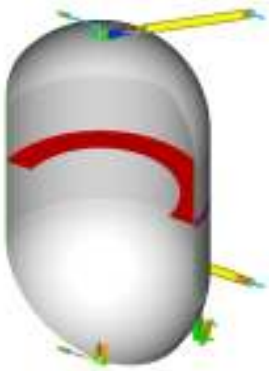
- PMD designed for LM in 2000
- Don Jaekle responsible for the PMD design & analysis
- Tank size: 56 cm Ø x 69 cm long (22 in Ø x 83 in long)
- Moderately complex trap, sponge, and slosh control device PMD
- ATK built 12 tanks to date, in production
- PMD designed for horizontal handling

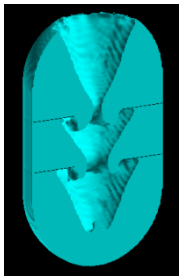
Marketing Level – Non Export Controlled

PMD Tanks from 2000's

MESSENGER PMD Tank (80433)

- PMD designed for Aerojet in 2000
- Don Jaekle responsible for the PMD design & analysis
- Tank size 56 cm Ø x 99 cm (22 in Ø x 39 in long)
- PMDs are baffles and a vortex suppressor
- Extensive PMD analysis during design and after launch





Mars Explorer Reconnaissance PMD

- PMD designed for Jet Propulsion Laboratory in 2001
  - Lightweight PMD for Mars mission
- Don Jaekle responsible for the PMD design and analysis
- Simple pickup tube and sponge PMD
- PSI built and delivered 8 PMDs
- Aluminum shell (built by someone else) failed to qualify for the mission because of high reject rate

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

LS-1300 PMD Tank (80441)

- PMD designed for Space Systems/Loral in 2001
  - Upgraded PMD with horizontal handling in existing tank shell
- Don Jaekle responsible for the PMD design & analysis
- Tank size 124 cm Ø x 147 cm (49 in Ø x 58 in long)
- Moderately complex trap, sponge, and vane PMD
  - With horizontal handling capability
- This tank is currently in production

LS-1300 PMD Tank (80442)

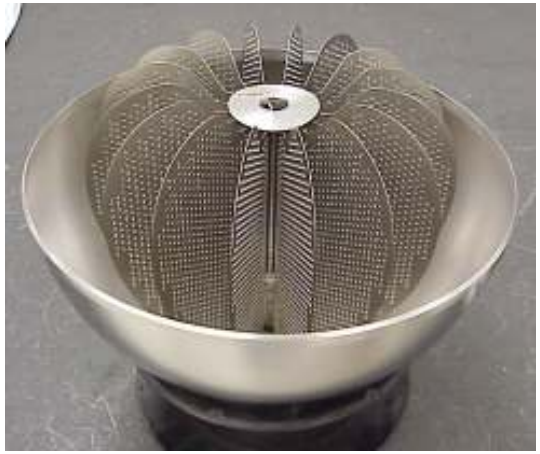
- PMD designed for Space Systems/Loral in 2001
  - Upgraded PMD with horizontal handling in existing tank shell
- Don Jaekle responsible for the PMD design & analysis
- Tank size 124 cm Ø x 160 cm (49 in Ø x 63 in long)
- Moderately complex trap, sponge, and vane PMD
  - With horizontal handling capability
- This tank is currently in production

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

Orbital Express PMD Tank (80454)

- PMD designed for Northrop Grumman
- Don Jaekle responsible for the PMD design & analysis
- Tank size 419 mm Ø (16.5 in Ø)
- Large sponge PMD
- Tank/PMD designed for both liquid and gas transfer



Proprietary PMD (80472/80473)

- PMD designed for proprietary customer in 2003
  - PMD tanks in a uni-body structure
- Don Jaekle responsible for the PMD design and analysis
- Complex PMD for bi-prop system

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

NFIRE PMD Tank (80462)

- PMD designed for Spectrum Astro in 2003
- Don Jaekle responsible for PMD design & analysis
- Tank size: 63 cm Ø x 74 cm long (25 in Ø x 29 in long)
- Simple center-posted 4-vane PMD
- PSI built 1 tank (Iridium shell w/ new PMD)

Extended PMD Tank (P/N 80470)

- PMD designed for MELCO in 2003
  - LEO observatory
- Don Jaekle responsible for the PMD design & analysis
- Tank size 103 cm Ø x 124 cm (40.5 in Ø x 49 in long)
- Simple sponge and vane PMD
  - Not designed for horizontal handling
- PSI qualified tank but customer never flew this tank

Marketing Level – Non Export Controlled

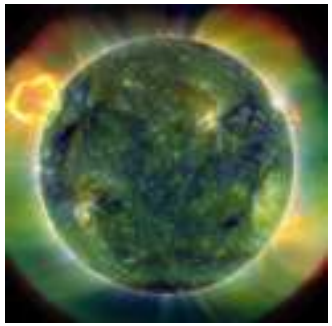
PMD Tanks from 2000's

MiTEx PMD Tank (80474)

- PMD designed for NRL in 2003
- Don Jaekle responsible for PMD design & analysis
- Tank size: 76 cm Ø (30 in Ø)
- Simple sponge PMD (no vanes)
- PSI built 5 tanks plus a qual tank
  - Flown successfully

SDO PMD Tanks (P/N 80484)

- PMD designed for NASA in 2004
  - Solar observatory
- Don Jaekle responsible for PMD design & analysis
- Tank size 107 cm Ø (42 in Ø)
- Large sponge for propellant CG control
- PSI built 2 tanks (flown)



Marketing Level – Non Export Controlled

PMD Tanks from 2000's

Wild Geese PMD Fuel Tank (80480)

- PMD designed for OSC in 2004
- Don Jaekle responsible for PMD design & analysis
- Tank size: 48 cm Ø (19 in Ø)
- Simple sponge and vane PMD
- PSI built 1 tank

Wild Geese PMD Ox Tank (P/N 80481)

- PMD designed for OSC in 2004
- Don Jaekle responsible for PMD design & analysis
- Tank size 34 cm Ø (13 in Ø)
- Sponge with dip tube (no vanes)
- PSI built 1 tank1

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

LS-1300 PMD Tank (80501 & 80502)

- PMD modified for Space Systems/Loral in 2005
  - Upgraded PMD with horizontal handling in existing and updated shells
- Don Jaekle responsible for the PMD design & analysis
- Tank size 124 cm Ø (49 in Ø)
- Moderately complex trap, sponge, and vane PMD
  - With horizontal handling capability
- This tank is currently in production

PMD Tank (P/N 80511)

- PMD designed for MELCO in 2007
- Don Jaekle responsible for PMD design & analysis
- Tank size 103 cm Ø ellipsoid (40.7 in Ø ellipsoid)
- Very flat domes
- Sponge and vane PMD
- ATK built 3 tanks plus a Qual Tank
- This tank is in production

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

702MP PMD Tank (80506)

- PMD designed for Boeing in 2007
- Don Jaekle responsible for PMD design & analysis
- Tank size: 69 cm Ø x 143 cm long (27 in Ø x 56 in long)
- Sponge and vane PMD
- This is a family of tanks with different cylinder lengths
- ATK built 4 tank + Qual tank
- This tank is in production

702MP PMD Tank (P/N 80507)

- PMD designed for Boeing in 2007
- Don Jaekle responsible for PMD design & analysis
- Tank size 116 cm Ø x 152 cm long (45.6 in Ø x 60 in long)
- Sponge and vane PMD
- This is a family of tanks with different cylinder lengths
- ATK built 1 tank
- This tank is in production

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

LS1300 PMD Tank (80517)

- PMD designed for SSL in 2010
- Don Jaekle responsible for PMD design & analysis
- Tank size: 124 cm Ø x 183 cm long (49 in Ø x 72 in long)
- Sponge and vane PMD
- This is an existing family of tanks with different cylinder lengths
- ATK built 2 tanks + Qual tank
- This tank is in production

AMP PMD Tank (P/N 80520)

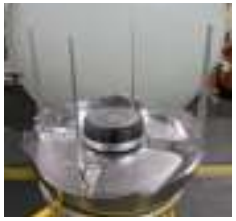
- PMD designed for Northrop in 2007
- Don Jaekle responsible for PMD design & analysis
- Tank size 116 cm Ø x 152 cm long (45.6 in Ø x 60 in long)
- Sponge and gallery arm PMD
- ATK built 1 tank + 1 Qual

Marketing Level – Non Export Controlled

PMD Tanks from 2000's

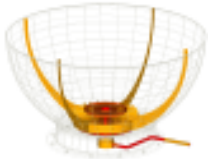
Cygnus PMD Tank (80527)

- PMD designed for OSC in 2010
- Don Jaekle responsible for PMD design & analysis
- Tank size: 76 cm Ø x 112 cm long (30 in Ø x 44 in long)
- Complex PMD: sponge, vanes, trap, galleries
- Space Station Resupply Mission
- ATK built 15 tanks + Qual tank
- This tank is in production



LADEE PMD Tank (P/N 80540)

- PMD designed for Loral in 2007
- Don Jaekle responsible for PMD design & analysis
- Tank size 38 cm Ø (15 in Ø)
- Sponge and vane PMD
- Successful Lunar mission
- ATK built 1 tank (new PMD in existing shell)



Marketing Level – Non Export Controlled

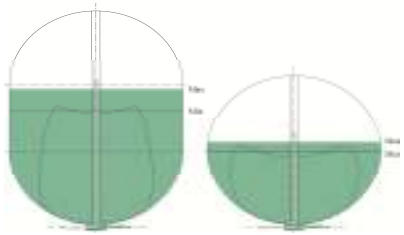
PMD Tanks from 2010's

JWST PMD Fuel Tank (80545)

- PMD designed for Northrop in 2010
- Don Jaekle responsible for PMD design & analysis
- Tank size: 67 cm Ø x 96 cm long (26 in Ø x 38 in long)
- Large sponge PMD for CG control
- Fuel Tank
- ATK built 1 fuel flight tank + Qual tank
- Extensive slosh testing

JWST PMD Ox Tank (P/N 80546)

- PMD designed for Northrop in 2010
- Don Jaekle responsible for PMD design & analysis
- Tank size 67 cm Ø (26 in Ø)
- Large sponge PMD for CG control
- Ox Tank
- ATK built 1 ox flight tank



Marketing Level – Non Export Controlled

PMD Tanks from 2010's

SkySat PMD Tank (80568)

- PMD designed for ECAPS in 2012
- Don Jaekle responsible for PMD design and analysis
- Tank size: 13 cm Ø x 33 cm long (5 in Ø x 13 in long)
- Simple vane PMD
- For new LMP 103 Green Propellant
- ATK built >30 tanks

702MP-Stretch PMD Tank (80576)

- PMD for new commercial satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 116 cm Ø x 236 cm long (45.6 in Ø x 93 in long)
- Upgraded (longer) PMD
- Qualification complete

Marketing Level – Non Export Controlled

PMD Tanks from 2010's

New ComSat PMD Fuel Tank (80563)

- PMD for new commercial satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 127 cm Ø x 165 cm long (50 in Ø x 65 in long)
- Largest diameter PMD tank
- New PMD
- Qualification complete

New ComSat PMD Ox Tank (80564)

- PMD for new commercial satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 127 cm Ø x 96 cm long (50 in Ø x 38 in long)
- New PMD
- Qualification complete

Marketing Level – Non Export Controlled

PMD Tanks from 2010's

New ComSat PMD Fuel Tank (80570)

- PMD for new commercial satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 116 cm Ø x 241 cm long (45.6 in Ø x 94 in long)
- New PMD
- Qualification complete

New ComSat PMD Ox Tank (80571)

- PMD for new commercial satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 116 cm Ø x 115 cm long (45.6 in Ø x 45 in long)
- New PMD
- Qualification complete

Marketing Level – Non Export Controlled

PMD Tanks from 2010's

Proprietary PMD Tank (80577)

- PMD for proprietary satellite
- Don Jaekle responsible for PMD design and analysis
- Tank size: 60 cm Ø x 139 cm long (28.5 in Ø x 54.9 in long)
- PMD upgrade from P/N 80398 PMD

New ComSat PMD Ox Tank (80585)

- PMD for lunar lander
- Don Jaekle responsible for PMD design and analysis
- Tank size: 76 cm Ø (30 in Ø)
- PMD is modified from P/N 80435 PMD

Marketing Level – Non Export Controlled