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NASA - Glenn Research Center
Seal/Secondary Air Delivery Workshop
October 29, 1999

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- Introduction -- Rocket Turbomachinery Shaft Seals
  - Inter-Propellant-Seal (IPS) Systems
  - 'Lift-off' Seal Systems
  - Technology Development Needs
- Rocket Engine Characteristics
  - Engine cycles, propellants, missions, etc.
  - Influence on shaft sealing requirements
- Conclusions

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- IPS Purpose
  - Separate incompatible fluids
  - Limit propellant leakage

- Technology advancement needs
  - Reduction or elimination of buffer gas consumption
  - Reduce or eliminate drain requirements
  - Reduced length of seal system
  - Higher allowable seal surface velocities

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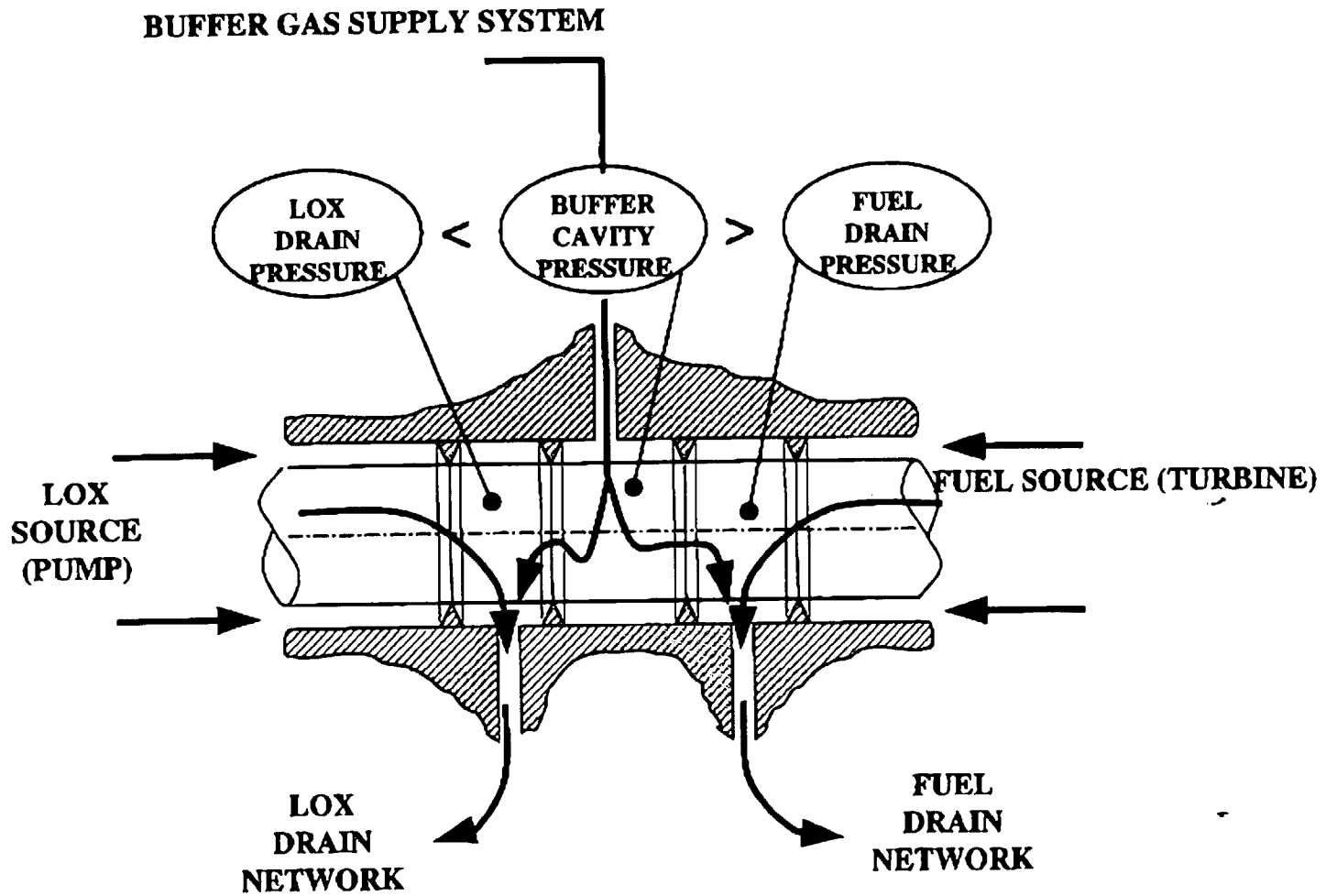

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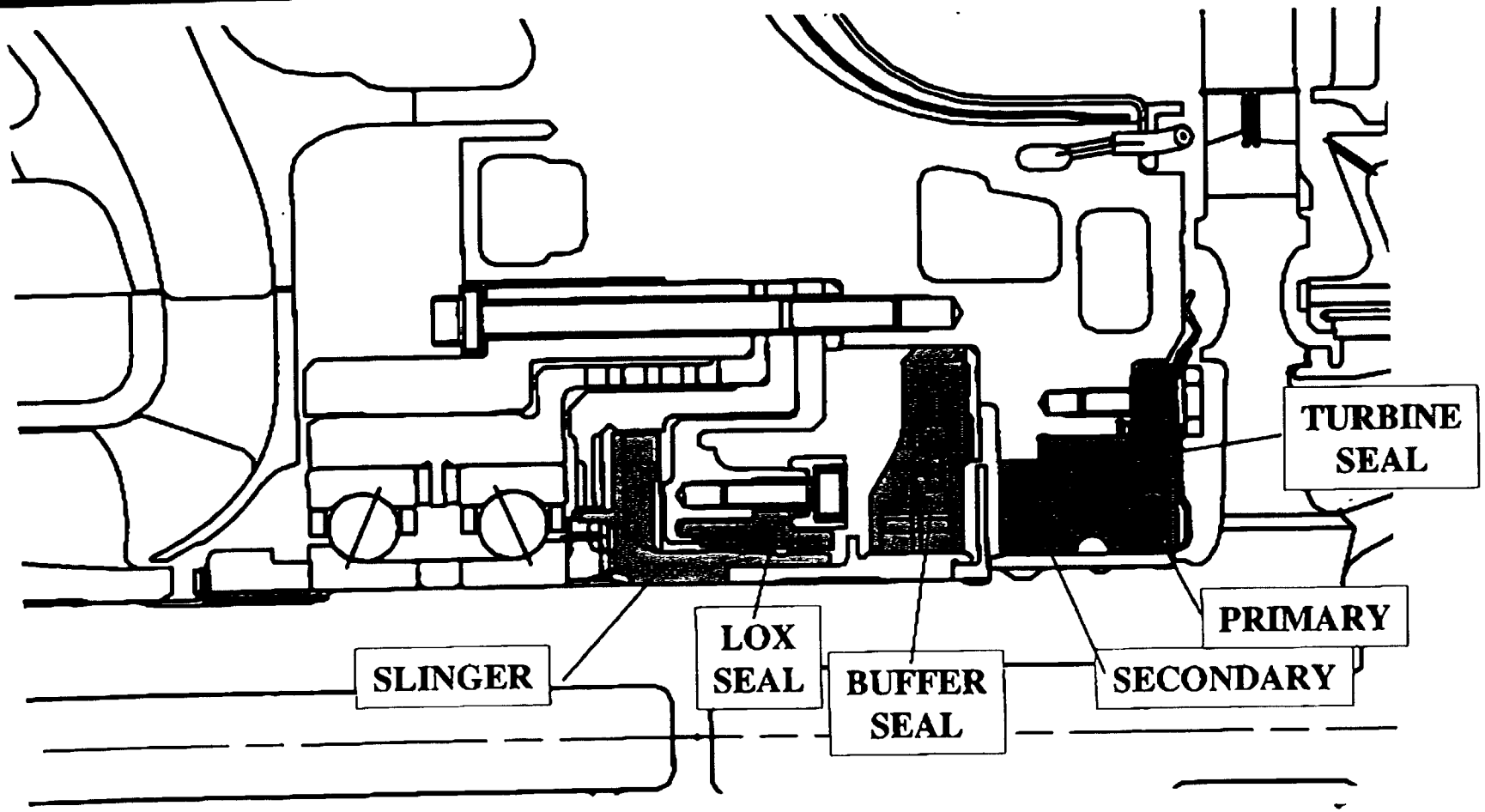

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Turbine Seal System

- **Purpose**
  - **Prevent propellant leakage into turbine before start and after cut-off**
  - **Limit leakage into turbine during operation**

- **Technology advancement needs**
  - **Reduction in seal system length (all-in-one seal)**
  - **Elimination of overboard drain/vent line**

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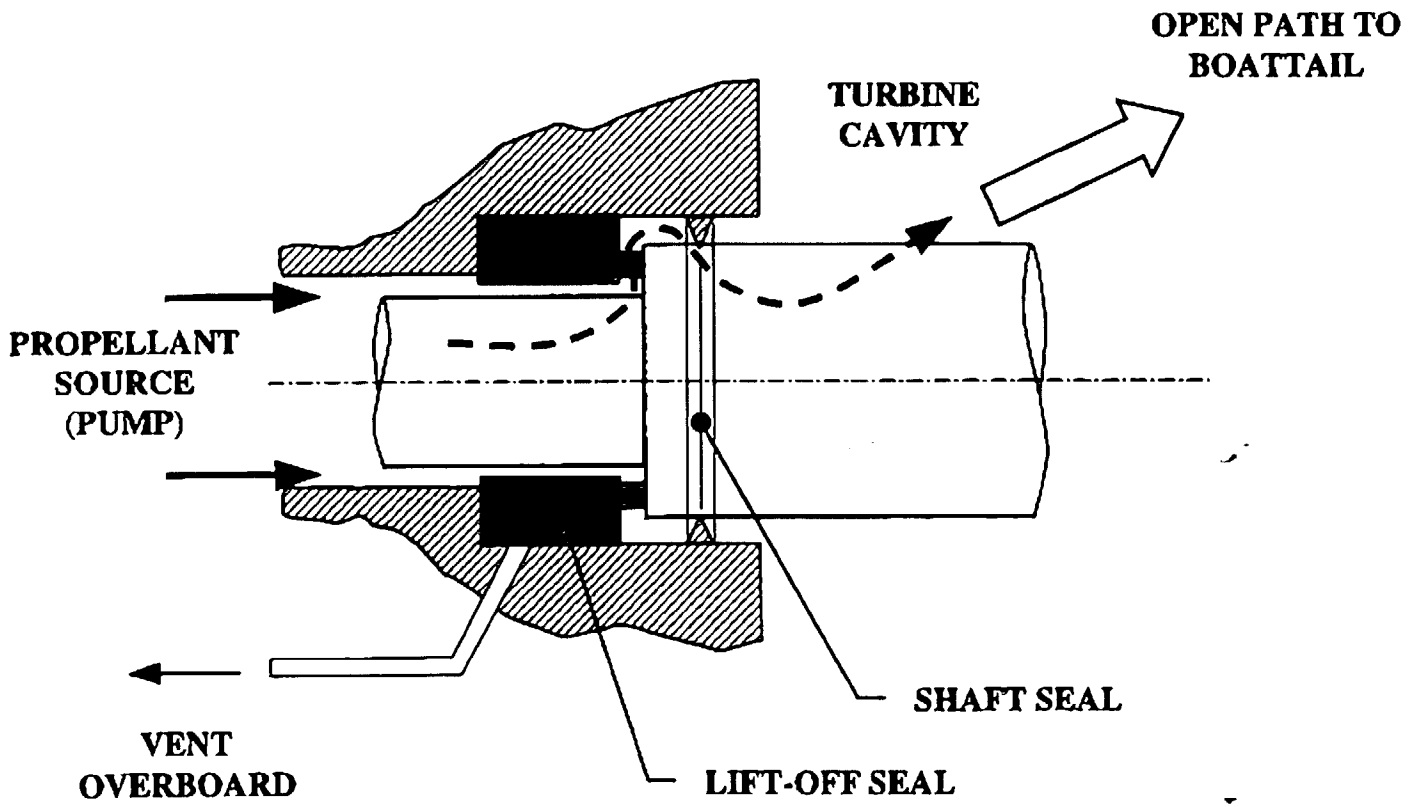

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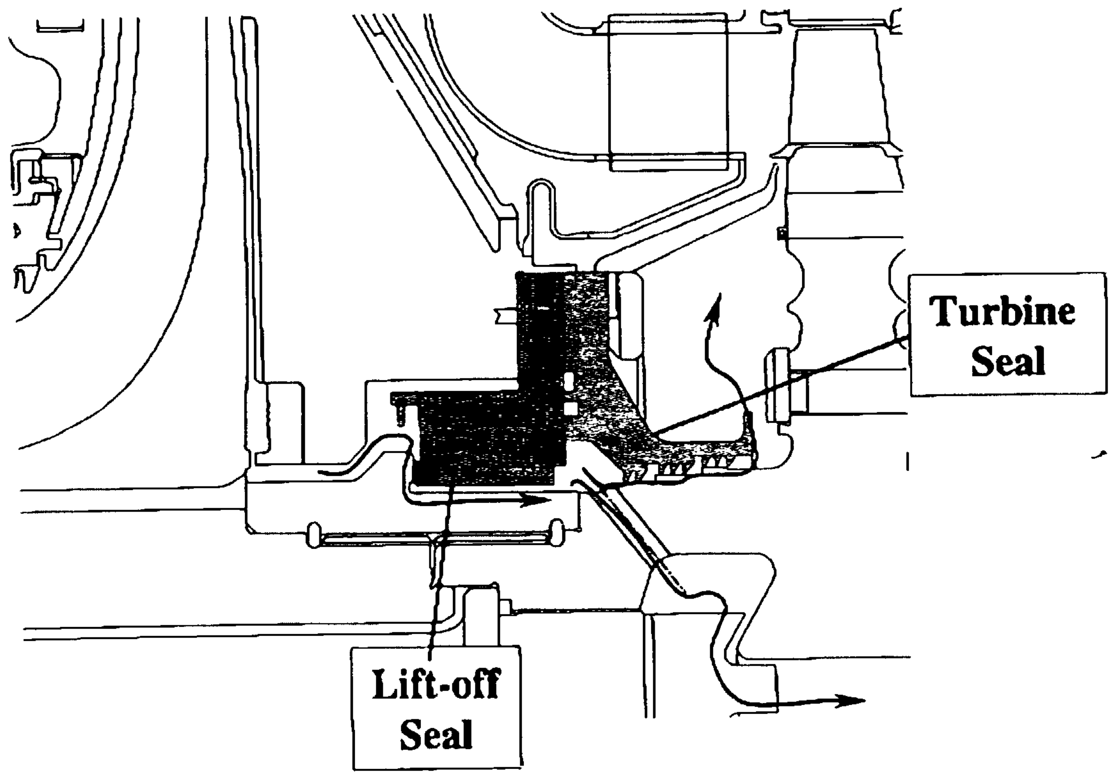
SSME HPFTP Lift-off Seal System



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Rocket Engine Classifications

Engine Cycle

'Open' Cycle
- Gas Generator
- Expander Bleed

'Closed' Cycle
- Staged Combustion
  - Fuel Rich
  - LOX Rich

Propellants

Cryogenic
- LOX -- LH2
- LOX -- Kerosene

Storable
- NTO -- MMH, UDMH, etc..
- H2O2 -- Kerosene

Mission

- Booster
- Upper Stage
- Single Stage-to-Orbit

Other

Expendable Vs. Reusable

Man Rated Vs Non-Man Rated

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Cycle defined by fluid source used to drive turbines

'Open' Cycle -- Turbine drive gas exhausted downstream of Main Combustion Chamber (MCC)

- Gas Generator Cycle -- Fuel-rich combustion products
- Expander Bleed Cycle -- Propellant, vaporized and heated by MCC exhaust

Influence on shaft seals:

- Relatively low turbine cavity pressures
- Impulse turbine -- low turbine flow rate effected by seal leakage

'Closed' Cycle

- Staged Combustion - Partial combustion of propellants, turbine exhausts into MCC injector head

Influence on shaft seals:

- Very high pressure in turbine cavity
- Relatively high turbine flow rate compared to seal leakage

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- Booster
  - High thrust -- high propellant flowrates, large pumps
  - Weight and performance less critical than upperstage and STO
- Upper Stage
  - Low thrust -- low flowrates, small pumps
  - Restart requirement
  - Weight and performance critical
- STO
  - Wide throttle range, large pumps
  - Weight and performance very critical

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Engine Cycle	Propellants	Booster	Upper Stage	Vehicle	Thrust
Gas Generator	LOX - RP1	F1		Satum 5	
	LOX - RP1	RS-27		Delta	200,000 SL
	NTO - A50	LR-87		Titan	550,000 Vac
	NTO - A50		LR-91		100,000 Vac
	LOX - LH2	RS-68			
	LOX - LH2		J2		
	H2O2 - RP1		AR-2		
	NTO - UH25	Viking		Ariane 4	150,000 SL
	NTO - MMH		L9	Ariane 5	5,700 Vac
	NTO - A50		AJ10		10,000 Vac
Expander	LOX - LH2		RL-10	Centaur	25,000 Vac
	LOX - LH2		LE-5	H2	27,000 Vac
Staged Combustion - Fuel Rich	LOX - LH2	SSME			375,000 SL
	LOX - LH2	Vulcain		Ariane 5	225,000 SL
	LOX - LH2	LE-7		H2	190,000 SL
Staged Combustion - Oxidizer Rich	LOX - RP1	RD-180		Atlas 3	
	LOX - RP1		RD-120	Zenit	187,000 Vac
	NTO - UDMH	ODU		Soyuz	
	NTO - UDMH	RD-253		Proton	330,000 SL
	NTO - UDMH		RD-0210	Proton	135,000 Vac

PRELIMINARY

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- **Conclusion -- New propulsion systems for launch vehicles inevitably place new demands on shaft seal systems that are not adequately met with existing seal technology.**

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