# Appendix E

# Preliminary List of Interface Issues and Considerations

## Table E.1 Chamber/Driver Interface Issues and Considerations

**I. Heavy Ion Driver**

*Final Magnets Design*

- Radiation damage to final focus (FF) magnets
- Gammas, neutrons, heating of superconductor
- Activation of FF magnets / waste generation
- Stand-off distance from FF magnet to target
- Array design (number, packing, angle of array, shielding)
- Keeping vacuum in magnet region
- Radiation confinement

*Beam Propagation and Focusing*

- Clearing beam path at high rep-rate
  - Droplets for liquid wall and wetted wall
- Background gas/vapor effect on beam
  - Vapor condensation (scheme dependent)
- Multiple beam effects (e.g., beam crossing)
- Beam instrumentation for beam pointing
- Neutralized ballistic
  - Beam stripping concern
  - Plasma source
- Z-discharge channels
  - Radiation damage of discharge systems
- Self pinch transport (validate concept)

*Illumination Geometry Considerations*

- Compatibility with target
- Beam port (chamber penetration) design
  - Crossing liquid jets
  - Flow around penetrations (wet walls)
- Condensation of materials in beam lines
- Beam/structure clearance (possible breakdown)
- Beam/liquid clearance (e.g., crossing liquid jets for thick liquid chamber)

*Driver cost*

**II. Laser Driver**

*Final Optics Design*

- Damage to final optics
  - x-ray, debris, gammas, neutrons, shocks, thermal effects
- Activation of optics / waste generation
- Vacuum boundary – radiation confinement (laser optic or window)

*Beam Propagation and Focusing*

- Clearing beam path at high rep-rate
  - Droplets for liquid wall and wetted wall
- Background gas/vapor effect on beam
  - Vapor condensation (scheme dependent)
  - Overlapping beams near target
- Stand-off distance from final optics to target (pointing)
- Beam instrumentation for beam pointing

*Illumination Geometry Considerations*

Array design (indirect drive)
Number, packing, angle of array
Shielding
Illumination geometry
Compatibility with target
Beam port design
Crossing liquid jets (thick liquid)
Flow around penetrations (wet walls)
Condensation of materials on optics
Beam/structure or beam/liquid clearance (effect on shielding)

*Driver Cost*

**III. Z-Pinch**

*Design of Interface*

Shielding of insulator stack
Activation of interface region
RTL connection to driver
Vacuum
Electrical
Structural
Tolerances for uniform power flow

*Rep-Rate Operation*

Reproducibility of RTL parameters
Recovery/separation and refabrication of RTL materials
Remaining solids?

*Driver Cost*

## Table E.2 Driver/Target Interface Issues and Considerations

1. Heavy Ion

| | nominal parameters |
|---|---|
| 1.A.1 Targets (Indirect Drive) | |
| spot size | 1-6 mm |
| number of beams | 16-500 |
| beam uniformity | . |
| spatial distribution | 10-30 deg (1/2 angle) |
| beam energy and balancing | |
| beam-plasma interactions in the target | . |
| beam steering (sensitivity to mismatching) | . |
| pulse shaping | . |
| 1.A.2 Targets (Fast Ignition) | |
| 1.A.3 Targets (Direct Drive) | |
| 1.B. Standoff Issues | |
| focusing | . |
| beam compression | . |
| beam transport mode | . |
| unneutralized ballistic transport | |
| neutralized ballistic transport | |
| channel-like transport | |
| stability in final transport | |
| beam uniformity | . |
| beam emittance (focusability) | . |
| neutralization effects | . |
| 1.C. Final Driver Parameters | |
| ion type | . |
| beam particle energy | . |
| total beam energy | |
| number of beams | |
| pulse shape | |
| beam emittance | |
| beam uniformity | |
| driver efficiency | |
| beam position micro-management | |

2. Laser

| | nominal parameters | |
|---|---|---|
| 2.A.1 Targets (Direct and Indirect Drive) | direct | indirect |
| wavelength | . | . |
| pulse shaping | | |
| irradiation uniformity | | |
| spot size | | |

number of beams
beam uniformities
spatial distribution
beam energy
beam balancing
interaction and energy transport in target
beam steering and zooming (x,y,z direction)

2.A.2 Targets (Fast Ignition)
?

2.B. Beam Transport Issues
standoff of the final optics
beam degradation and refraction by background medium

| 2.C. Final Driver Parameters | goal | achieved |
|---|---|---|
| wavelength | nm | |
| laser energy | MJ | |
| number of beams | # | |
| coherency control | | |
| pulse shape (contrast ratio) | | |
| final optic fluence | J/cm^2 | |
| repetition rate | Hz | |
| lifetime | x10^8 | |
| efficiency | | |
| beam synchronization | | |
| line width (bandwidth) | nm (Hz) | |
| beam position micro-management | | |

3. Z-pinch

| 3.A. Target (indirect) | |
|---|---|
| type | . |
| peak current | |
| pulse length | |
| load impedance | |
| drive voltage | |
| total energy | MJ |
| pulse shaping | |
| symmetry | . |

3.B. Standoff
recyclable transmission line (RTL)
alternate stand-off schemes
materials, coatings and fabrication
structural integrity and stiffness
vacuum requirement
turn-on uniformity
power flow uniformity

acceptable mass
RTL position macro-management

3.C. Driver

pulse energy
peak current
pulse length
drive voltage
pulse shape
rep-rated pulsed power, method and rate
reproducibility

## Table E.3 Target/Chamber Interface Issues and Considerations

1. Pre-shot target handling

1.A Target fabrication

| | |
|---|---|
| feasibility to make materials | |
| development of mass production processes | 5-10 Hz |
| cost per target | |
| demonstration of mass-production layering | |
| development of rapid QC (characterization) methods | |

1.B Safety and environmental issues

| | |
|---|---|
| material choices (activation, disposal, chamber compatibility) | |
| minimum tritium inventory | |

2. Target Heating and Mechanical Response during Injection

2a. Indirect drive (HI)

| | |
|---|---|
| no issues at 100 m/s | |

2b. Direct drive

| | |
|---|---|
| 2b1. Thermal radiation | |
| FW temperature | <1000 C |
| Target surface reflectivity | >95% |
| DT insulation | >100 μm |
| 2b2. Target heating by gases | |
| chamber fill gas pressure | <5 mTorr |
| chamber clearing of residual gases | <1 mTorr |
| target spin (perp. to spin axis) | yes |
| DT insulation | >100 μm |
| 2b3. Target survival criteria | |
| initial temperature of injection | 4-18 K |
| allowable DT surface finish | 1-10 μm RMS |

3. Target placement (x,y,z)

3a. for indirect drive

| | |
|---|---|
| placement accuracy | <1-5 mm |
| tumbling (yaw/orientation) accuracy | 100 μm |
| aerosol | |

3b. for direct drive

| | |
|---|---|
| placement accuracy | <1-5 mm |
| aerosol | |
| chamber gasdynamics | 1 mTorr fluctuation |

4. Target tracking

| | |
|---|---|
| 4a. Indirect drive | |
| perpendicular to axis | 100 μm |
| parallel to axis | 300 μm |

4b. Direct drive
accuracy 20 μm (w/zooming)

5. Target Emissions
energy-time-angular dependence of direct and indirect drive
ions and debris
x-rays
neutrons
off-normal yield

6. Chamber responses

6a. Dry wall protection
1. Design and materials
2. Space, time and energy irradiation and deposition
First Wall
Blanket
Back wall
3. Heat removal
4. Tritium
Inventories
Breeding rate
Extraction
5. First wall surface damage
Erosion
Sputtering
Impulse (shock) loading
Vaporization/ablation
Oxidation
Protective gas recovery
6. FW neutron effects, properties degradation
7. Neutron damage in back wall and blanket
Lifetime vs. material composition
8. Safety and Environment
Source term radioactivity (activation)
Routine operations
Dispersion and Transport of radionuclides (confinement)
Potential emission
Shielding
Accidents
LOCA – loss of coolant
LOFA – loss of flow
LOVA – loss of vacuum
Potential emissions
Waste generation vs. component lifetime
Decommissioning, disposal

6b. Thick liquid wall
1. Design and materials

2. Space and time irradiation
    liquid wall/blanket
    back wall
3. Ablation and venting
4. Condensation
5. Liquid disruption
6. Jet (pocket) regeneration
7. Tritium
    breeding
    inventory
    extraction
8. Coolant chemistry control
9. Structural wall effects
    neutron damage, lifetime vs. material
    corrosion, erosion, thermal startup
10. S&E (see above)

6c. Wetted wall

1. Design and materials
2. Space and time irradiation
    Blanket
    Structural wall
3. Ablation, shocks
4. Condensation
5. Liquid disruption
6. Film flow control, wetting & dryout, droplets, dripping
7. Tritium
    breeding
    inventory
    extraction
8. Coolant chemistry control
9. Structural wall effects
    neutron damage, lifetime vs. material
    corrosion, erosion, thermal startup
10. S&E (see above)

6d. Density gradient wall (e.g., fiber first wall)

Similar to dry wall