Report from the Off-normal Shots Working Group

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ARIES meeting

Livermore, CA

March 8-9, 2001

This report will cover three areas

- Specifications and Requirements for IFE Radiation Preheat Direct Drive Targets (Dan Goodin)
- Speculations on Off-normal Shots for KrF Lasers (John Sethian)
- Design Impact of Off-normal Shots

Target Specifications - Draft

Foam Shell	Value	Units	Tolerance (±)	Comments
Composition	C, H, O, N			
Oxygen-max a/o	TBD			
Nitrogen-max a/o	TBD			
Thickness	289	microns	20	equivalent to 3 micron of full density plastic
Outer diameter	4	mm	0.2	
Density	20	mg/cc	5	
Pore size	1	microns	must be < 3	
Impurity levels	TBD			
Out-of-Round	1	% of radius		
Non-concentricity (Wmax – Wmin)	1	% of average wall thickness		
Areal density uniformity	< 0.3	% density variation		Equivalent to 500 Å of material at the average density of the mixed DT/foam

Target Specifications - Draft

Seal Coat	Value	Units	Tolerance (±)	Comments
Composition	C, H, O, N			
Oxygen – max a/o	35	a/o		
Nitrogen – max a/o	20	a/o		
Thickness	1	micron	1	must provide smooth surface and prevent DT evaporation
Density	1.4	g/cc	+ 0.2, - 0.05	
Surface Finish	< 500	Angstroms		
Permeability	TBD			

Target Specifications - Draft

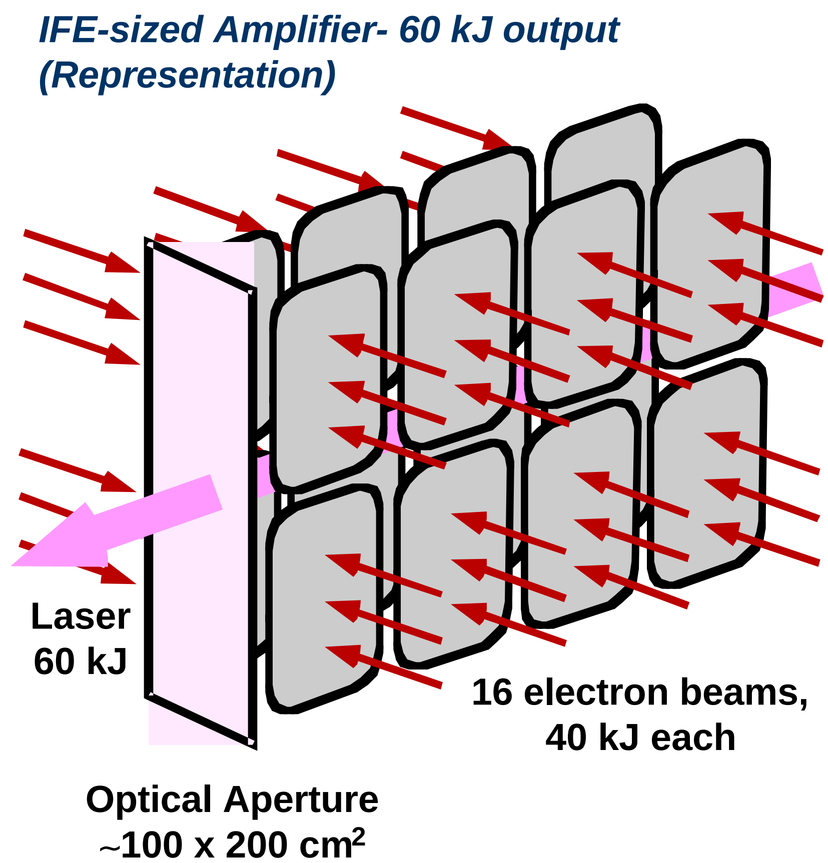
Gold Overcoat	**Value**	**Units**	**Tolerance (±)**	**Comments**
Thickness	325	Angstroms	50	
Density	20	g/cc	5	
Impurities	TBD			
Surface Finish	< 500	Angstroms		Over lengths of 20 to 100 microns (modes 100 to 500)
Uniformity	10	% of gold thickness		
Filling	**Value**	**Units**	**Tolerance (±)**	**Comments**
Wicking	Capability to fill with DT at room temperature and retain DT at cryo. Must "wick" DT into foam at cryotemperatures and fully wet the foam (no bubbles).			
DT thickness	190	microns	20	
Target Injection	**Value**	**Units**	**Tolerance (±)**	**Comments**
Placement	+ / - 5	mm		
Alignment of drivers on target	+ / - 20	microns		
Heatup of DT ice	1.8	Kelvin		Actual requirement is highly uncertain

Speculations on Off-normal Shots for KrF Lasers

- The KrF laser system has not been optimized at this time, so we cannot define what is off-normal and what is acceptable variation within the system.
- The largest factor for determining fault probability is electrical breakdown in the pulsed power system.
- An initial design allows us to understand possible modes of failure of the system.

Representative, IFE-sized Amplifier with 60 kJ output

(one of 32 beam lines)



There are Two Primary Causes for Laser Faults

- Pulsed power electrical breakdown in the e-beam system and failure of the pressure foil that confines the laser gas.
- There are other components that could break, but these are the most sensitive.
- Each of these events will be described here.

Pulsed Power Electrical Breakdown

- A liquid dielectric stores electrical energy that is used to drive the e-beam. A short circuit arc through the oil or water insulator dissipates electrical energy so the e-beam is not fully powered.
- The breakdown may be repairable, depending on location and other circumstances. If energy is deposited in the dielectric, it is easily repaired. Energy deposited in the casing could breach the casing. Generally a breakdown cannot be repaired in the 200 msec inter-shot time.
- Breakdown in the pre amp or driver amp takes that beam line down, and you lose 1 of 32 beams.

Pressure Foil Breach

- The pressure foil isolates the laser gas from the e-beam diode. If the foil breaches, the gas can escape and you have lost that beam line, and 3% of the laser energy to the target.
- The foils can be designed for high reliability and frequent replacement, so that foil failure between maintenance sessions is an extremely unlikely event.

Speculations on Annual Probabilities of These Two Events

Component	Laser energy lost per failure	Pulsed Power failure-recoverable	Pulsed Power failure-non recoverable	Foil failure non-recoverable[4]
Front end[1]	3%	0.1%	0.1%	0%
Pre-amplifier[2]	3%	1%	1%	0.5%
Driver Amplifier	3%	1%	1%	0.5%
Main Amplifier	0.4% or 3%[3]	5%[5]	5%[5]	1%

1. Front end will probably be a discharge system, with no foils or high voltage systems. This technology is being used by the semi-conductor industry and should be very reliable.
2. The smaller pre-amp and driver amp can be made more reliable as they will not be as highly stressed electrically.
3. Lose 0.4% for pulsed power failures, 3% for foil failures.
4. Foil failures are necessarily low, because we ought to be able to design long lived foils.
5. Can be made lower, if need be, but we need to have a good reason to do it.

Design Impact of Off-Normal Shots

- In discussions with Bob Peterson of U-W, he indicated that BUCKY could be used to calculate:
  - Output spectra from reduced yield shots
  - Pellet acceleration due to asymmetric illumination in zero yield shots
- To proceed with these calculations, Bob needs authorization from the ARIES project management.

backups

Initial Laser Reliability Assessment requires a Design

- An initial design allows us to understand the possible modes of failure of the system
- Assume a 1.92 MJ laser. 32 beam lines, each having a main amplifier with an energy output of 60 kJ. Amplifier configuration: 16 e-beams, each 40 kJ input, and 80% transmission efficiency gives 512 kJ into the laser gas. The laser efficiency is 12%, so 60 kJ is output. There are 8 pulsed power systems, each 80 kJ for each of the 32 amplifiers. This is a total of 256 pulsed power systems.

Additional Components are Needed in the System

- There is also a front end that starts the seed laser, then pre-amplifiers, and driver amplifiers for each laser beam line.
- 1 front end for all 32 beam lines.
- 2 pre-amplifiers for each of the 32 lasers
- 2 driver amplifiers for each of the 32 lasers
- 8 main amplifiers for each of the 32 lasers