Laser Certification Review

NCLC

Certified Laser Repair Technician

The Laser Training Institute™

Professional Medical Education Assn

www.LaserTraining.org

Written Examination

- 155 Multiple Choice Questions
  - 1 Correct (Best) Answer
- 70% Required for Passing
  - can miss up to 46 Questions
- 4 Hours allotted for completion
- Closed Book. “Controlled” breaks allowed.

Certification Status

- Full Certification requires successful completion of the proctored examination, plus the experience and background requirements.
- Course participants may submit the additional materials at a later time, and have up to 5 years to complete the experience requirement.
- Those passing the exam but still awaiting completion of other requirements are designated a “Certification Candidate” and will receive the appropriate Certificate.

Exam Content Areas

The examination is NOT a test of specific service procedures on specific lasers as defined in their service manuals.

The examination tests for a knowledge of laser and optical concepts including some specific alignments that are common among all lasers, and representative laser repair scenarios.

Exam Content Areas

The areas of testing for various NCLE Laser Certifications basically boil down to the areas of:

(1) Laser Concepts
(2) Tissue Effects, and
(3) Safety

- as defined by the American Society for Laser Medicine & Surgery, and ANSI in their recommendations.

Exam Content Areas

For the CLRT Credential:

Safety – 16% 25 Q

Laser & Energy Concepts – 33% 51 Q

Laser Repair/Technical – 47% 73 Q

Tissue Interactions – 4% 6 Q

of Questions by Area

SAFETY

- Administrative – 2
- ANSI Regulations – Agencies – 6
- Eye-Skin Hazards – 7
- Non-beam Hazards – 2
- Hazard Evaluation & Control – 1
- Safety Practices - 7

of Questions by Area

LASER & ENERGY CONCEPTS

- Physics - 8
- Optical Principles - 14
- Energy Concepts - 5
- Wavelength Identification - 8
- History - 1
- Equipment Considerations - 15

of Questions by Area

LASER REPAIR / TECHNICAL

- Alignments - 10
- Case Studies - 19
- Optics Cleaning - 2
- Optical Principles for Service - 14
- Power Measurement - 7
- Tubes & Resonators - 7

of Questions by Area

LASER REPAIR / TECHNICAL

- Power Supplies - 7
- Component I.D. - 5
- Safety Practices for Service -2
- Flashlamps - 3

of Questions by Area

TISSUE INTERACTIONS

- Thermal – 4
- PhotoAcoustic – 1
- PhotoChemical – 1
- PhotoDisassociation - 0

Review Format

Each slide in this review will relate to the "Content Area" classification of a specific question on the exam, but will not be specific about the question asked.

Each slide will note the category of the content area covered, and it is possible that more than one question is asked within that slides content area.

Laser Safety

ANSI LASER CLASSIFICATIONS

- Classes 1-4
- All Surgical Lasers are Class 4
- Class 4 – all precautions required all the time in the NHZ
- Anything over 0.5w avg power or anything that burns eye or skin is Class 4

Repair / Technical

- Review the required sequence of alignments in any laser. Power Tweaking, Aiming beam coincidence, Delivery system
- Proximal changes affect all “downstream” optics.

Laser & Energy Concepts

- Characteristics of Fibers
  - Transmitting vs Contact Tip Fibers
  - Bare Fibers versus Handpieces & other Delivery Optics (i.e. slit lamps)
  - Fiber divergence
  - Principles of total internal reflection created by changes in refractive index
  - Typical fiber sizes
  - Wavelengths amenable to fiber transmission

Laser & Energy Concepts

- Power Density (PD) effects on Tissue
- Power Density Parameters
  - Spot Size (Rapid Change)
  - Power (Slower Change)
- Techniques of changing Power Density with different delivery devices (i.e. focusing or collimated handpieces, bare fibers, waveguides)
- Too High PD is “clean” but loses control
- Too Low PD is controllable, but causes charring, burning and scarring.

Repair / Technical

- Ion Laser Power Supply Characteristics
  - Rectified AC Line Voltage ~ 240v
  - Passbank Current or Voltage Regulation
  - Typical 30-50 amp draw
  - Tube voltage at full operational power or current is best gauge of tube condition. – actually looking at the combination of V&I condition is better.
  - Over voltage = Tube Overpressure (burn off)
  - Low Voltage = Tube Underpressure (fill from reservoir – "ballast tank" – caution not to overfill)

Repair / Technical

Ion Laser Tube Components

- Ceramic or Glass bore (tube)
- Surrounding Magnet to "squeeze" the ionized plasma into the middle of the bore
- Anode / Cathode
- "Getter" which pulls out impurities such as hydrogen which may be in the tube
- Brewster windows at each end to seal the tube

Laser & Energy Concepts

HISTORY

- Einstein – theory of stimulated emission based on photovoltaic cells
- Schawlow / Townes – theoretical paper on optical masers
- Ted Maiman – First Laser – Ruby
- Dr Goldman – father of lasers in medicine

Laser & Energy Concepts

Surgical Laser Fibers

- Transmitting fibers that diverge 10-20 degrees, can touch tissue or be used off tissue
- "Contact" fibers that have sharp or ball tips that simply get hot and cut tissue
- Sapphire contact tips added to the end of the fiber catheter that converts the light energy into heat and works almost exclusively as a "hot knife"

Laser & Energy Concepts

LASER ACRONYM

L IGHT
A MPLIFICATION, by the
S TIMULATED
E MISSION of
R ADIATION

HINT: When a slide contains ONLY one bullet point, or one item such as this, you're pretty much assured that you're look at the answer to a question. You just have to match it to the right question on the test.

Repair / Technical

- CW Dye Laser Characteristics (I.E. Photodynamic Rx for Cancer)
  - Uses incoming beam from an Argon or KTP laser as it's power supply.
  - Produces CW Red light at about 630 nm
  - Spherical Integrators required to measure energy from many types of diffusers.
  - Monochrometer required to measure wavelength stability.

Repair / Technical

Dye Solutions in Dye Lasers

- Dye replacement part of normal maintenance and it needs regular maintenance, including running of the laser
- Degraded dye solution shows up as lower energies from the laser, misfires, and wavelength instability of the output.
- Dye consists of the dye concentrate and typically uses an antifreeze (ethylene glycol) carrier along with C.O.T., and is considered a hazardous solution.

Repair Technical

Watts & Joules Conversion

- Watts x Seconds – Joules
- 1.5 J at 10hz will show as 15w avg pwr (15J in one second)
- When measuring avg pwr at 10hz, just divide by 10 to get the J/pulse

Laser & Energy Concepts

- Typical Power/Energy Display & Measurement:

General Rule

- CW Lasers – Watts
- Pulsed Lasers – Joules or MilliJoules

(Even though you can use a power meter head to measure a pulsed laser by adjusting the rep rate.)

Laser & Energy Concepts

- Typical Power/Energy Display & Measurement:

- Watts: CO_2, CW Nd:Yag, CW Dye, Argon, Many Surgical Diodes
- Milliwatts: Ophthalmic Diode Laser
- Joules: Ho:Yag, Alexandrite, Ruby, Pulsed Dye for vascular, Q-Switched Tattoo Nd:Yag
- Millijoules: Q-Switched Ophthalmic Nd:Yag, Pulsed Dye Green for lithotripsy

Repair / Technical

Q-Sw Ophthalmic Yag – Alignment

- The capsule which is the target is right against the new lens so pitting this lens must be avoided.
- Deferring to mfg specs, alignment of the red dot & spark is centered on X-Y axis, but the spark is placed just "behind" the red dot in the Z axis (depth) so that the red dot focuses on the capsule and the spark occurs just behind it to create the shock wave to rip the membrane, but sparing the lens.

Repair / Technical

Use of Attenuators:

- Aiming beam brightness
- Some sealed tube CO_2 Lasers because unstable at very low currents.

Repair / Technical

Diode Laser Troubleshooting

- Calibrated annually
- It either works or not – no optical assemblies except for delivery optics, and no optical adjustments.
- Total power output is frequently the sum of multiple diodes.
- Diodes are also used as the pump source on some solid state lasers. (DPSS Lasers)

Repair / Technical

Brewster Windows

- Purpose – enhance transmission (reduce reflections)
- Angle – 57.3 degrees (for quartz) – where the surface does not reflect the light of one linear polarization
- Importance of keeping clean – power loss in ion laser.
- Can be used anywhere, but typically in ion lasers. (Argon & Krypton Ion Lasers)
- Use of protective covers that are sometimes pressurized with gas flow to reduce dust.

Laser & Energy Concepts

Time Periods (usually related to pulsing)

- Seconds or Milliseconds, 10^{-3}s, usually "long" pulse (i.e. Hair lasers typically 10-100ms)
- MicroSeconds – Faster Pulses ~ 10^{-6}s frequently associated with shock waves (i.e. Ho:Yag Lithotripsy)
- NanoSeconds & PicoSeconds 10^{-9} & 10^{-12}s – "sparking" as in (i.e. Q-Switched or Mode Locked lasers)

Laser & Energy Concepts

PULSING

- "Gated" (timed) vs. true Laser Pulse
  - Electrical Control or Mechanical Chopper
- Electrically "Spiking" the driving current
- Acoustic Optical & Electro Optical
- Optical Crystals & Cells
  - Pockel's Cells for Q-Switching, nanosecond
  - Dye Cell for Mode Locking, picosecond train

Repair / Technical

CO_2 Laser Gases

- Laser Gas Mixture – Mostly He, lesser N_2, and lowest % CO_2. N_2 gives it the characteristic purple/pink color.
- Sealed tube lasers – added catalysts/inhibitors.
- Purge Gases – compressed air, or bottled N_2. Needs to be filtered. Only keeps smoke off the lens.
- Problems with tank swapping between Laser Gas and N_2 purge gas.

Laser & Energy Concepts

Handpieces

- Focusing Handpieces – mostly for incisions/ablations. Shorter the focal length the smaller the spot & shorter the depth of field.
- Collimating Handpieces – mostly for aesthetic use – larger spot sizes and keeps it the same regardless of slight movements – consider hazards at distance.

Repair / Technical

LAMPS (Flash Lamps)

- Pressurized – explosion hazard – eye protection & caution required.
- Cleaning precautions – no rigorous rubbing – clean gently like an optic.
- Failure may be gradual – symptoms of repeated start attempts & “cracking” noise (bad D.I. water can mimic this)

Repair / Technical

LAMPS (Flash Lamps)

- Typical life of 150-200 hours CW
- Typical 100K to 250K shots Pulsed
- Anode / Cathode – Note the polarity
- Flow-Tube used to direct the water tightly around the lamp for cooling – must be kept clean.

Repair / Technical

Laser Output Calibrations

- Recommended annually (per Mfg specs)
- +/- 20% Variance – High, Mid, Low
- CFRs require that manufacturers must provide detailed procedure upon request
- Your own external meter should itself be sent in for calibration to a national standard – suggested annually

Laser Safety

Skin Burns to Service Technicians

- Possible with any laser
- CO_2 greatest burn hazard
- Touching fiber outputs will burn even if the laser does not – including contact tips
- Electrical burns also possible

Repair / Technical

Laser Internal Power Detection

- CO_2 & Er:Yag use shutter to totally dump beam into calorimeter – so during use meter reading is only memory or current.
- Nd:Yag, KTP, Argon and others use a beam splitter to create a small optical “shunt” into the meter, so the meter reflect the actual value during use

Laser Safety

Hazardous Reflections

- Service personnel are exposed to open housings which create greater risks of accidental exposure
- Surgical instruments can be “anodized” to create a micro-rough surface and reduce reflections
- Instruments can be “ebonized” to make them black, but this is primarily to reduce reflections from light sources which impairs the physicians vision.

Laser & Energy Concepts

Radiant Exposure (Energy Density)

- Measured in Joules / cm^2
- Used when a "Dosage" parameter of the laser is required – also applies to IPL's.
- Generally used for Aesthetic/Derm procedures like hair removal – vascular lesions, etc.

Repair / Technical

Practical Optical Principles

- Remove, Clean or Adjust
  -- ONLY ONE OPTIC AT A TIME.
- In an Optical train – adjusting any optic will affect all the optics downstream of that one.
- Don't unnecessarily remove Optics for cleaning if they may be adequately cleaned in place.

Repair / Technical

Pulse Energies vs. Pulse Rate

- Pulse Energy in Joules x Rate (prr) creates an "average" power in watts.
- Higher average powers don't necessarily mean a more "powerful" impact
- Higher energies require longer recovery time and hence lower maximum rates. – i.e. -shows up as problem if Q-sw NdYag is foot activated too rapidly.

Laser Safety

Direct Beam Hazards

- Eye burns or damage
- Skin burns
- Fires or burning of materials
- Accidental surgical perforations or incisions

Laser Safety

Indirect Laser Hazards

- Laser Plume
- Electrical – this is probably the most significant hazard to Repair Technicians, including direct laser beam hazards.
- Dyes & Solvents
- Laser Gases

Laser & Energy Concepts

Wavelength Identification
8 Questions on Exam

CO_2 – 10.6u Nd:Yag 1.064u Nd:Yap 1.34u Er:Yag – 2.94u Ho:Yag – 2.1u Alexandrite – 755nm Helium Neon (HeNe) 632nm	Ruby – 694nm Gold Vapor – 632nm CW Dye (PDT) 632 ArFl Excimer 193nm XeCl Excimer 308nm KTP (KDP) – 532nm Argon – 488, 515nm Krypton – 647, 568, 531nm	Diodes - ~ 530-1500nm Copper Bromide 577,511 Pulsed Dye, ~594nm (Vascular) Pulsed Dye Grn, 604nm (Lithotripsy)

Repair / Technical

Anti Reflective Coatings (AR Coatings)

- Used to increase efficiency of optical "coupling" into optic & reduce losses.
- Coating faces the incoming laser beam.
- Coating is ¼ the wavelength of the laser
- Works by destructive interference pattern
- Identify by "V" or seeing the backside edge at a critical angle
- Inserting them wrong reduces the power output at best, and can destroy proximal optics at worst

Repair / Technical

Near / Far Alignments (for most – not all - lasers)

- "Near" beam is closest to HeNe (aiming) and is reflective.
- "Far" beam is the beam combiner which passes the surgical laser & reflects the HeNe (aiming).
- Alternate between Near / Far adjustments
- Bring the HeNe back on top of the Burn spot each time.
- Note the mode structure when burning
- Checked on CO_2 by burning tongue blade and observing coincidence – use the delivery system that will actually be used during the case (focal lengths).

Laser Safety

Airway Fires

Though not directly related to laser service work, the consequences are so catastrophic that all laser personnel should be aware.

When using the laser directly in the airway, standard PVC (polyvinyl chloride) endotracheal tubes should NOT be used – and laser resistant tubes used instead.

Repair / Technical

Beam Paths & Alignments – IR Lasers

- Thermal paper of any source
- Zap-It paper for visualization
- Fluorescent Plates & UV illumination
- Infrared viewing scopes
- Anything to burn with CO_2 lasers

Repair / Technical

½ Way !

Articulated Arm Alignments

- To center the beam on the rotational axis of each arm mirror
- Place tape mark on aim beam, then rotate 180 degrees & observe
- Adjust aim beam ½ way to mark, & continue back & forth until corrected.
- Centering is a byproduct at the end of correct alignments and you never try to center the aiming beam by adjusting it directly to the center

Laser Safety

Retinal Hazards

- All wavelengths which pass through fluid
- Incorporates all visible light lasers
- Between approximately 400nm – 1400nm
- Practical difference between hazards of visible vs infrared.
- Lens of eye increases power density by 100,000

Repair / Technical

Power / Energy Measurement

- Meter, plus various heads
- Generally heads for power in watts, and energy in joules.
- Can use a watt meter for some pulsed lasers if use prr of 10 hz.
  (1J x 10pps = 10W, or 10 J in 1 second)
- Importance of using large spot to avoid burning surface of meter.

Repair / Technical

Front / Rear power mirrors

- Front mirror is the Partially Reflective, "Output Coupler" (OC), beginning of optical train.
- Rear mirror is High Reflectivity (HR), and is optically isolated from optical train so may be adjusted independently.
- "Walked" as a pair to peak power output

Repair / Technical

Flowing Gas CO_2 Lasers Vacuum System

- Insufficient vacuum allows more molecules in tube & higher power output, but becomes unstable at low powers.
- Higher vacuum "thins out" the molecules and lowers max power output but increases the stability of low power outputs.

Repair / Technical

Flowing Gas CO_2 Lasers Vacuum System

- Excessive vacuum can cause arcing of the anode/cathode and potential damage to laser electronics.
- Vacuum leaks can cause intermittent firing – especially at lower powers.
- Mfg's procedures should be followed for doing a vacuum check on the system, and the high voltage circuit disabled.
- Vacuum pump oil changes or vane "resetting" can sometimes correct intermittent problems.

Repair / Technical

Ho:Yag Optics

- High energy pulses are hard on fibers and internal optics.
- "Blast Shield" used to protect laser optics from fiber fragments when exploded.

Laser Safety

Laser Plume (smoke from tissue)

- Obnoxious at best, and infectious at worst
- Smoke evacuation required by ANSI whenever plume is created.
- Treat tubing and filters as contaminated
- "Viral sized" face masks are considered ineffective and don't replace smoke evacuation, but no prohibition from using them with a smoke evacuator.

Repair / Technical

Deionizer Cartridge / Crystals

- Required when coolant flows over anode/cathode of flashlamps to prevent conduction.
- Discoloration of crystals or conductivity of fluid can indicate need for change.
- When deteriorating, laser can suffer power losses or show intermittent firing.

Laser & Energy Concepts

PHYSICS

- Stimulated vs Spontaneous Emission
  - Theory by Einstein as it related to photovoltaic
- Transition levels of electrons including metastable states
- Planck's constant defines differences in energy bands and resulting wavelengths

Tissue Interactions

Pulsed Laser "shock wave" applications

- Q-switched Nd:Yag, Ophthalmology for posterior capsulotomy (secondary cataracts)
- Ho:Yag laser, Urology, lithotripsy
- Pulsed Dye laser (green), Urology, lithotripsy
- Q-switched Ruby, Nd:Yag, KTP for tattoos

Tissue Interactions

Laser Interactions

- Low Level Light (laser) Therapy – (Photobiomodulation) aka biostimulation or "cold" laser for chronic pain treatment, hair growth, skin rejuvenation, wound healing, etc.
- Thermal – non lethal heat – tissue welding, skin rejuvenation
- Thermal – destructive heat – cutting, ablating, photocoagulation, aesthetics, selective photothermolysis
- Acoustical shock waves – lithotripsy, photodisruption
- Photochemistry – PDT (Photodynamic Therapy)
- Photodisassociation – vision correction, Ar FL

Tissue Interactions

Free Beam Lasers (fibers or focused)

- Heat is generated when the light is absorbed in the tissue
- Wavelengths of lasers have various "chromophores" that absorb that specific wavelength

Laser Safety

Laser Operator Functions

- Ensure policies/procedures followed
- Signs on doors & windows covered when applicable.
- Glasses available, and worn in NHZ
- Aiming beam checked for alignment with surgical beam on every case.

Laser & Energy Concepts

Optical Principles

- All other things equal, smaller focal length lens results in smaller spot & smaller depth of field.
- Increasing the beam diameter (& lens) at the same focal length will result in a smaller spot.
- Shorter wavelengths may be focused to smaller spot sizes (diffraction limited spot size) than longer wavelengths, if taken to their maximum.
- Higher pulse energies and shorter wavelengths are "harder" on optics. (i.e. ArFl excimer)

Repair / Technical

Typical CO_2 Laser Power Supplies

- Flowing Gas & DC Excited Sealed Tube
  - DC, HV, Low Current, ~ 15-20KV, 15ma
- RF Excited
  - RF power in watts and frequency determined by mfg.
  - Power supply is "supposed" to be tuned to that specific waveguide resonator cavity.
  - RF transmitted transversely across the cavity

Laser Safety

Suggested Hierarchy of Laser Eye Hazards:

- Pulsed Dye Yellow – because of high peak powers and absorption of yellow by retina
- Infrared lasers – because no aversion response
- Visible light lasers – have aversion response
- CO_2, ErYag & ArFl lasers (have lenses that focus at some short distance.) Corneal hazard.
- Ho:Yag – because of divergent fiber. Corneal

Repair / Technical

Output from Multi-Line Lasers

- Max power output is sum of all wavelengths when they may be emitted simultaneously.
- Ar, Kr, CuBr lasers – all multi-line
- Single line emission will have lower power outputs than maximum multiline.

Tissue Interactions

Relevance of pure color to application

- Photodynamic Therapy (PDT) – photochemistry
- Ophthalmology
- Dermatology/Aesthetic
- General Surgical free beam
- General Surgical hot tips or contact tips

Repair / Technical

Basic Lens/Mirror Classifications

- Plano
- Concave
- Convex
- Plus combinations for both sides of lenses.

Laser & Energy Concepts

Laser Beam Properties

- Collimated – minimally divergent, like any point source of light.
- Coherent – phased wave patterns, up to a certain distance from output. More important for sensing & diagnostics.
- Monochromatic – narrow bandwidth lines of "color", even if multi-line.

Laser & Energy Concepts

Laser Beam Properties

- Collimation –
  Probably the most important aspect for medical use because this is a "point source" of light with rays traveling parallel. Optics will focus this down to diffraction limited spot sizes (very small spots).

Laser & Energy Concepts

Laser Beam Properties

- Collimation –
  All other things being equal, the larger the diameter of the beam, the lower the divergence. Beam expanders are used to do this for transmitting laser beams over long distances (non-medical use).

Repair / Technical

Frequency Doubling

- Usually done on Nd:Yag lasers to change (halve) wavelength to 532nm green.
- KTP (Potassium Titanyl Phosphate) frequency doubling crystal usually used, although KDP or others may also be used.
- Usually configured as a high frequency "quasi-continuous" pulsed system of over 20Khz. (I.E. Laserscope KTP laser)

Laser & Energy Concepts

Electromagnetic "Radiation"

- One of the four forces of the Universe (also strong & weak forces, & gravity)
- Spans the range from short cosmic and gamma rays to long radio waves
- Visible light is in a very narrow range from around 400-700nm
- Measured as Angstroms, nanometers or micrometers (5320A, 532nm, .532um)

Laser Safety

¾ Way!

Practical Safety Practices for Laser Service

- "Awareness" of hazard & possible exposure to stray & direct beams. Involves "observing & clearing" the area prior to working.
- Avoiding placing your face in direct line with the output coupler
- Exercising precaution with power supplies – the greatest hazard to service people.

Laser Safety

Laser Protective Eyewear

- Should always be worn within the NHZ
- Does NOT guarantee protection from direct impacts from the laser beam
- Must be labeled according to the wavelengths & Optical Density (O.D. or degree of protection).
- O.D. is a logarithm. I.E 10^4 = OD 4, so a change from 4-7 is a 1000 fold increase in attenuation.

Laser Safety

Maximum Permissible Exposure (MPE)

- Maximum exposure limit for eye & skin before a burn results
- This is what actually determines the boundaries of the NHZ
- Measured & Calculated by industrial/scientific safety officers, but medical LSO's may rely on other means.

Repair / Technical

Optics – Chromatic Aberration

- The same lens will focus different wavelengths to different focal lengths
- Focused on a surface (tissue) this can cause the aiming & surgical beams to be significantly different spot diameters.
- In the real world, this can also cause loss of coaxialness between the aiming beam and surgical laser

Repair / Technical

Cooling Systems – CO_2 lasers

- Distilled water, or sometimes antifreeze solutions just to avoid problems in transportation in cold climates.
- Algae growth is biggest problem – change water & add inhibitors
- Vapor locks in water pumps sometimes stop flow – purge lines.

Repair / Technical

Cooling Systems – lasers with 3 phase pumps (i.e. older Nd:Yag)

- Polarity of the phases controls the direction of rotation of the motor
- Impellor on pump is designed to spin one direction – ensure that the phasing is correct for this – can do a "quick" test to see.
- Running the pump with incorrect phasing rotates the impellor the wrong way and can shear it from the shaft so that water flow stops.

Repair / Technical

Cooling Ion Laser Tubes

- Some lasers have flow sensors (proteus wheel) & others may not (or may be broken).
- All have overheat sensors (thermistors) that will shut down the unit
- Forgetting to turn on the external water source is the primary reason for overheats
- Panicking & turning the flow back on just after such a shut down can crack the tube and cause extensive damage. – Let it sit untouched for a while before attempting a restart or turning on water.

Laser Safety

PREGNANCY

- The "Radiation" referenced on Laser warning signs is not ionizing radiation and poses no threat to women in any stage of pregnancy

Repair / Technical

Power Supplies – Pulse Forming Networks (PFN)

- Used by lasers that typically fire a flashlamp in a pulsed manner
- I.E., Pulsed Dye, Ho:Yag, KTP

Laser & Energy Concepts

Measurement of Beam Divergence

- Radian used as unit of measurement.
- Angular measure – ratio of the arc length on the circumference of a circle by that angle, divided by its radius.
- At 1 milliradian, the spot would increase by 1 foot for every 1000 feet in distance.
- Typical laser divergence is 0.5 – 10 milliradians.

Repair / Techical

Frequency of use and maintenance

- Some lasers should be run periodically (once per week?) or they will develop maintenance problems.
- Argon & Krypton ion lasers will because of potential overgassing in the tubes.
- Dye lasers will because of coatings of the dye & solvent on the tubes & internal optics.

Laser Safety

Physician Credentialing for Laser

- Physicians are licensed by their state medical boards for medical practice in that state regardless of the tools used,.
- Each health care facility sets its own standards for physician laser credentialing, according to ANSI recommendations.

Repair / Technical

Accessory Shutters & Filters

- Slip on filters over eyepieces
- Electromechanical Filters that rotate in place
  - Check for proper operation during service
  - Potential problems when firing too fast & not allowing sensor to reseat.

Repair / Technical

Launch of Ophthalmic Ar or Kr into Fiber

- 3 Axis alignment (X, Y, Z)
- Depth of focus is important because you do want to cover the face of the fiber as much as possible with the beam, rather than sharply focusing it on a small point on the fiber and burning it.

Repair / Technical

Ophthalmic Argon Spot Size Control

- Beam delivered through a slit lamp microscope
- Focusing lenses in the laser tower on the slit lamp that focus the beam
- Spot sizes from ~ 50u to 0.5mm
- Ophthalmologist frequently uses a handheld contact lens to allow additional deflection of the beam into the eye.

Repair / Technical

Selective Transmission/Reflection of Colors

- Dichroic Filter allows selective transmission of wavelengths.
- Dichroic filters placed “inside” the resonator cavity will allow lasing of only that wavelength.
- Principle employed in tunable Dye laser as the Birefringent Tuner to select certain wavelengths.

Laser & Energy Concepts

Active Mediums

- Nd:Yag – Neodymium
- Ho:Yag – Holmium
- Argon/Krypton – those gases
- Ruby – Chromium ion
- CO_2 – that molecule
- KTP – Neodymium
- Diode – the semiconductor

Laser Safety

Transmission of Light through Glass

- 300-2800nm
- Lasers that don't transmit through glass include CO_2, Er:Yag, Ar:FL, etc.
- Glass in optics of scopes & instruments afford protection to the viewer
- Window glass affords protection to outside viewers so that no coverings are required

Repair / Technical

Optics Cleaning – desirable hierarchy

Going from most gentle to roughest – levels of desperation

- Drop & Drag – sheet of lens paper
- Twist & wipe – folded paper in hemostat
- Roll & wipe – cotton tip applicator
- Rub & Scrub – cotton tip applicator

In practice, don't remove optics for cleaning unless they really need it and you can't adequately do it in place.

Repair / Technical

Fiber Calibrations

- In most bare fiber surgical applications this is unimportant from a practical point of view.
- Some lasers have external pod to point and shoot and no close contact is required with fibers
- Sapphire Contact Tips or urological side-firing fibers are NOT fired into a calibration port, or they will burn up.

Repair / Technical

Fiber Calibrations

- Some lasers have sleeves into which the fiber is inserted before firing into meter
  - Glass windows on some of these & some fibers can be burned if allowed to touch the window when firing
- In sterile procedures the sleeves must also be sterilized before doing the calibration & the fiber handled with sterile gloves

Repair / Technical

Laser Calibrations

- Meter, plus various heads for various lasers
- Avoid burning face of detector with small spots
- Can be calibrated through the delivery lens, but do NOT focus it on detector – fill about 75% of the face of the detector

Tissue Interaction

Laser Pulsing

- Higher Flux from laser pulses result in less thermal spread (better thermal precision) from the intended target when used in such thermal applications such as skin resurfacing, hair removal, removal of surface vascular marks, fine incisions, etc.

Tissue Interaction

Laser Pulsing

- At even higher flux of a pulse, the result is a "non-linear" thermal event and shock waves are produced.
- Fiber contact with object for lithotripsy
- Non-contact "sparks" created by Q-sw Nd:Yag for ophthalmology

Laser Safety

ALMOST THERE!

Service Training – ANSI recommendations

- Must have laser safety training
- Must have laser repair training commensurate with the level of work
- No requirements for any educational background or certification
- No requirements for authorization or approval by manufacturer

Laser & Energy Concepts

FLUX

- Concept of delivering more energy in shorter time periods to reduce thermal spread.
- 1W at .2s (.2J) is lower flux than 2W at .1s (.2J still).
- Look at the concept and balance of power and time

Laser Safety

ANSI Recommendations

- American National Standards Institute
- "Recommended" practices but not law
- Used for enforcement by OSHA, JCAHO and various states
- 136.1 Parent technical document, and
- 136.3 Safe Use of Lasers in Health Care Facilities

DONE!

Whew !!!!!