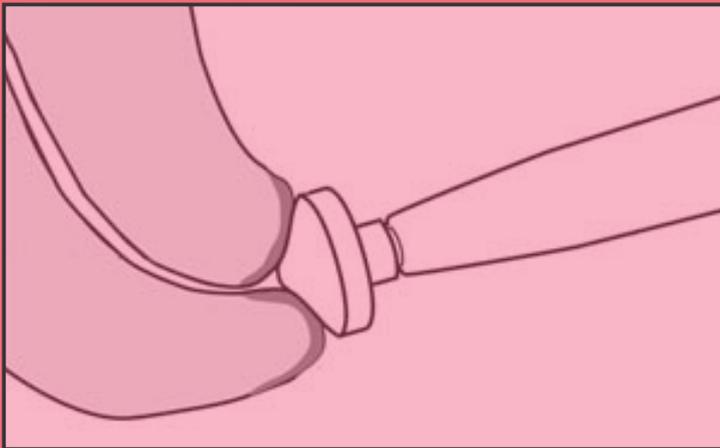


WHO technical specifications Cryosurgical equipment for the treatment of precancerous cervical lesions and prevention of cervical cancer



World Health
Organization

WHO technical specifications

**Cryosurgical equipment for
the treatment of precancerous
cervical lesions and prevention
of cervical cancer**

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This document is the result of a review of the latest available evidence and an extensive consultative process on the treatment of precancerous cervical lesions by cryosurgery. WHO, UNFPA, and PATH organized a joint meeting of clinical experts in cryosurgery in Seattle, March 30–April 1, 2009. The goal of the meeting was to build consensus on approaches to improving cryosurgical service delivery to prevent cervical cancer. The meeting had two areas of focus: to discuss clinical recommendations in the use of cryosurgery for cervical cancer prevention and to initiate development of technical specifications to facilitate country procurement. Meeting attendees included experts from different countries on obstetrics and gynaecology, and the use of cryosurgery to treat cervical precancerous lesions. Representatives from NGOs and advocacy groups, and representatives from two cryotherapy device manufacturers, Wallach and MedGyn, also attended the meeting.

The first meeting identified several key issues relating to technical specifications for cryosurgery equipment which required follow-up and further development. These included procurement, performance, and maintenance of cryosurgical devices and related equipment, such as gas cylinders and connectors. At that time a framework was developed to address these issues, including the formation of a technical specification working group.

A second meeting re-convened key members from the technical specification working group to finalize the technical basis and make recommendations for the development of a procurement specification to guide the purchase, use, and maintenance of cryosurgical devices. This document is based on the output of the second meeting, together with input from members of the technical specification working group and other experts listed below.

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Co-authors

William Potter (Consultant/WHO Technical Adviser) drafted the technical specification and supporting documents, with core contributions from Siavoche Mohadjer (WHO Consultant), Margaret Usher-Patel (WHO), Jennifer L. Winkler (PATH), Jered Singleton (PATH), Keith Neroutsos (PATH), and Nathalie Broutet (WHO).

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Meeting participants and members of the technical specification working group

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Executive Summary

Cervical cancer is a serious and growing global health issue. In 2008, there were approximately 274 000 deaths from the disease, about 88% of which occurred in developing countries. Although it affects women worldwide, cervical cancer mortality is highest in low-resource settings. Cryotherapy, also known as cryosurgery, has been widely accepted as a practical and effective method of treating precancerous cervical lesions. It is appropriate for use in low-resource settings because it is effective, has limited side-effects, does not require electricity, is inexpensive compared to other treatment options, and is technically simple to implement.

This document seeks to assist programme managers, purchasing managers, and other

interested parties with the procurement, management and effective use of cryosurgical equipment to treat precancerous cervical lesions as part of a comprehensive cervical cancer prevention programme. It provides an overview of the procurement and performance issues associated with some cryosurgical devices, gas supplies and gas cylinders, and necessary connectors. The document offers technical specifications for purchasers, including the design and performance recommendations necessary to ensure the safety and efficacy of cryosurgical equipment, issues related to the gases used by the equipment, and guidance on how to procure both the equipment and the gases. Annexes provide additional useful information.

Introduction

Cervical cancer is a serious and growing global health issue. In 2008, there were an estimated 529 000 new cases of cervical cancer and approximately 274 000 deaths, making it the second most common cancer in women. About 88% of deaths occurred in developing countries, of which 53 000 occurred in Africa, 31 400 in Latin America and the Caribbean, and 159 800 in Asia. In Eastern Africa, South-Central Asia, and Melanesia cervical cancer is the most common cancer killer of women.¹

Although it affects women worldwide, cervical cancer mortality is highest in low-resource settings where women have not traditionally had access to organized screening programmes. Infection with human papillomavirus (HPV), the virus that causes cervical cancer, is preventable through vaccination, but the vaccine should be given prior to infection, which often occurs within a few years of sexual debut. For those women already infected, development of cervical cancer is preventable using relatively simple, low-cost screening and treatment approaches that can be implemented at the district, if not primary, health care level. This is particularly true of visual inspection methods such as VIA (visual inspection with acetic acid) combined with cryosurgical treatment, although in certain cases more sophisticated treatment is needed². In many areas, treatment is provided the same day as a positive screening test, or soon after. It is usually provided without histological confirmation because of the potential loss to follow-up that would result from the extra diagnostic step. Cervical cancer usually takes decades to

develop, so there is time to catch it and treat it early. Physicians, nurses, and other health care providers can be trained to provide both VIA screening and cryosurgical treatment; expanding this service base greatly increases access for women.

Cryosurgery is appropriate for use in low-resource settings because it is effective (>90% cure rate), has limited side-effects, does not require electricity, is inexpensive compared to other treatment options, and is technically simple to implement. The results of long-term trials demonstrating the effectiveness of “screen and treat”, or VIA and cryosurgical interventions, has prompted health care providers in middle- and low-income countries to scale up national programmes incorporating this approach.

The WHO Reproductive Health Strategy, adapted by Member States during the 57th World Health Assembly in 2004 (WHO/RHR/04.8), recognized and highlighted cervical cancer prevention and control as one of five major reproductive health priorities. A recent WHO report called cervical precancer screening using VIA and cryotherapy a “best buy” for the control of non-communicable disease³.

That said, a successful programme requires confidence in both the screening method and the equipment necessary to treat lesions. Cryosurgical equipment has not always inspired such confidence. Failure to achieve freezing and gas line blockages are two problems that have been seen in the field. In response, the WHO Department of Reproductive Health and Research (WHO/RHR), in partnership with PATH and UNFPA, mobilized technical advisors, researchers, and manufacturers to develop procurement specifications for cryosurgical equipment, gas, and accessories, along with technical guidance for addressing operational

¹ Ferlay J, Shin HR, Bray F, Forman D, Mathers C and Parkin DM. *GLOBOCAN 2008 v1.2, Cancer Incidence and Mortality Worldwide*. IARC CancerBase No. 10 [online database]. Lyon, International Agency for Research on Cancer, 2010 (<http://globocan.iarc.fr>).

² *Comprehensive Cervical Cancer Control: A guide to essential practice*, World Health Organization, 2006 (<http://www.who.int/reproductivehealth/publications/cancers/9241547006/en/index.html>).

³ Screening still the “best buy” for tackling cervical cancer, *Bulletin of the World Health Organization*, September 2011, Vol.89.9: 621-700

challenges and a consensus configuration of a standard cryosurgical package.

For more information about cervical cancer screening and treatment, consult WHO's [C4-GEP] and other documents which can be found in the "Screening" section of the RHO Cervical Cancer Library (www.rho.org).

Who is this document intended for?

This document is intended primarily for any policy-maker, manager, or procurement officer who has responsibility for procuring, supplying, and promoting the early prevention and management of cervical cancer. Individuals working in reproductive health care programmes, particularly STI/HIV/AIDS prevention and family planning programmes at the district and primary health care level, should also review this document to understand why it is vitally important to establish systems which ensure that a quality product is manufactured, procured, and used. Bulk procurement agencies and national regulatory authorities will also need to study this document in preparation for the manufacture, procurement, and supply of cryosurgical equipment and the appropriate

procurement, use, and management of the gas supply needed to operate the equipment.

In addition to these primary users, the document will be useful to manufacturers, social marketing programmes, nongovernmental agencies, and policy-makers as they work to improve the acceptability and use of cryosurgery as a means to support cervical cancer prevention and management programmes in their target populations.

Purpose of the document

This document describes a technically sound, systematic process to support the procurement and distribution of cryosurgical equipment that can meet the needs of cervical cancer prevention and management programmes at the district and primary health care levels. It includes advice on technical specifications for purchasers, including the design and performance recommendations necessary to ensure the safety and efficacy of cryosurgical equipment. It also discusses issues related to the sources, storing, and handling of gases used by the equipment, and guidance on how to procure both the equipment and the gases.

Chapter 1.

Generic specification of cryosurgical equipment for the treatment of precancerous cervical lesions

1.1 Scope

This *Generic Specification* specifies requirements and recommendations for cryosurgical equipment for the treatment of precancerous cervical lesions in low-resource settings. The specification is based on a series of meetings, surveys, reviews, and studies undertaken between 2008 and 2010 by WHO, PATH, and UNPFA⁴.

1.2 Background to cryosurgical equipment

Cryotherapy, also known as cryosurgery, has been widely accepted as a practical and effective method of treating precancerous cervical lesions worldwide. Extreme cold is applied to the lesion using a cryoprobe (an extremely cold probe) to freeze the lesion. The World Health Organization Guidelines on the use of cryotherapy for cervical intraepithelial neoplasia strongly recommend the use of cryotherapy over no treatment.

Cryosurgical equipment (also known as cryotherapy equipment) is available from a number of manufacturers, mainly US-based, but with some types available from European and Indian manufacturers. Two main methods are used to cool the cryoprobe: the expansion of

a compressed gas through a nozzle, causing cooling by the Joule-Thomson effect, and the use of cryogenic liquids such as liquid nitrogen. Because of the risk of damaging surrounding tissue when using cryogenic liquid-based cryosurgical equipment, and the potential problems associated with the sourcing, delivery, storage, and handling of liquid nitrogen in low-resource settings, only compressed gas-based cryosurgical equipment is recommended for the treatment of precancerous cervical lesions.

Although current cryosurgical equipment relies on using a compressed gas or a cryogenic liquid to achieve the target probe temperature, new types of equipment with built-in freezer units are beginning to emerge. By eliminating the need for compressed gas supplies, units with built-in freezers may have clear advantages in low-resource environments despite their potentially higher initial purchasing costs. The suitability of this type of equipment for use in low-resource settings still has to be assessed but may well represent an opportunity for the future.

The most widely-used compressed gases for surgery are carbon dioxide and nitrous oxide, and most cryosurgical equipment manufacturers offer the option of using either. The choice of gas has to be made at the time of purchase of the equipment to ensure the proper fittings, and in some cases that the appropriate device is used. In low-resource settings carbon dioxide is often cheaper and more readily available than nitrous oxide.

Examples of some of the main suppliers that have been identified through internet and other searches are given in Table 1.

1.3 Equipment requirements

Cryosurgical equipment operating on either compressed carbon dioxide or nitrous oxide may be used for the treatment of precancerous

⁴ Meetings, surveys, reviews and studies:

- The 2008 WHO/UNPFA/PATH Survey of Cryotherapy Practitioners
- The 2008 WHO/UNPFA/PATH Cryotherapy Market Survey
- Bench testing of four cryotherapy devices with nitrous oxide and carbon dioxide in Peru, 2009
- Discussion held by the Technical Specifications working group during the March 30-April 1, 2009: Building a consensus on approaches to improving cryotherapy service delivery to prevent cervical cancer
- Meeting report from Cryotherapy Technical Specifications and Procurement Guidelines, September 23rd and 24th, 2010.

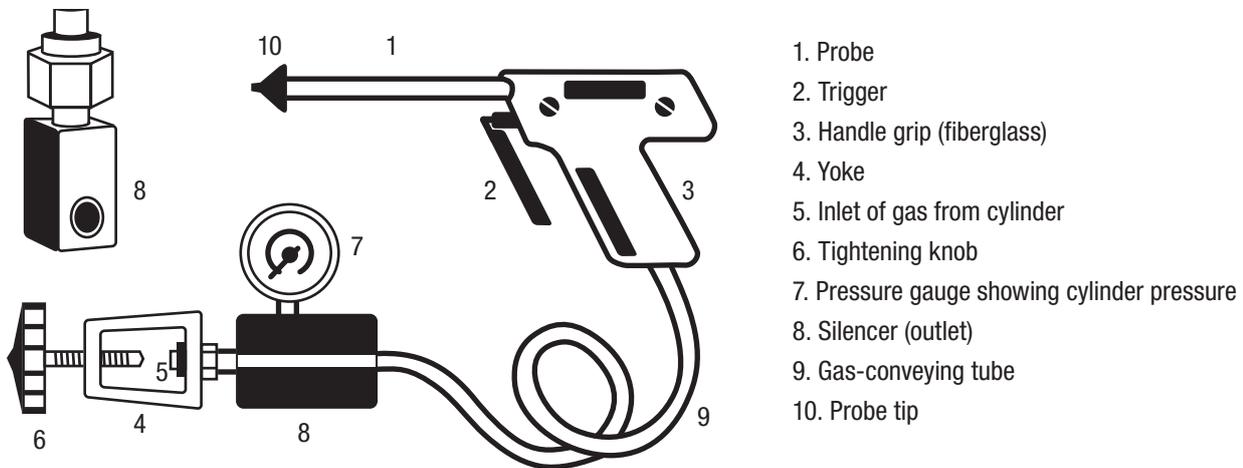
Table 1: Suppliers of cryosurgical equipment suitable for cervical lesions

Company	Country	Models	Gas	Manufacturer Contact Details
Leisegang (Cooper-Surgical)	USA	LM-900 Cryosurgical	CO ₂ or N ₂ O	www.coopersurgical.com +1 203 601 9818
Wallach	USA	LL100	N ₂ O only	www.wallachsurgical.com +1 203 799 2000
Wallach	USA	LLC02	CO ₂ only	www.wallachsurgical.com +1 203 799 2000
Wallach	USA	WA1000B	CO ₂ or N ₂ O	www.wallachsurgical.com +1 203 799 2000
Ascon Medical Instruments	India	Not stated	CO ₂ or N ₂ O	www.asconmedical.com +91 44 22254420
Frigitronics (Cooper-Surgical)	USA	Surgical Plus CM-73	CO ₂ or N ₂ O	www.coopersurgical.com +1 203 601 9818
MedGyn Products	USA	Cryotherapy System	CO ₂ or N ₂ O	www.medgyn.com +1 630 627 4150
Basco India	India	Super Deluxe Silencer Gun Model: CRYO-004	N ₂ O	www.basconline.com +91 44 2371 5699
ERBE Elektromedizin	Germany	Erbokryo CA Erbokryo 12	CO ₂ or N ₂ O	www.erbe-med.com +49 7071 755-0
Appasamy Assoc.	India	Cryo Super Model AA1 and AA2	CO ₂ or N ₂ O	www.appasamy.com +91 44 32980153

cervical lesions. In low-resource settings carbon dioxide is generally more readily available and costs less. An example of a typical cryosurgical unit is shown in Figure 1.

The equipment comprises the following components:

- A hand unit with a shaft to which detachable probe tips can be attached.
 - The hand unit is made of a material that withstands routine sterilization or disinfection with hospital disinfectants, including bleach solutions or any other disinfectant for surgical instruments. The manufacturers' recommendations for sterilization and disinfection should be followed.
 - The hand unit is fitted with one or more integrated triggers and other controls
 - to regulate the gas flow, and therefore the temperature, to control the freezing-thawing cycle.
 - An "active defrost" mechanism is preferred but not essential.
 - The trigger mechanism should be designed to give the user sensory feedback, indicating whether the device is in the on or off position.
 - There should be a latching or ratchet mechanism allowing the user to lock the trigger in the on position.
 - The trigger has a release mechanism to unlock the trigger and return the device to the off position.
 - The controls are located such that they can be operated with just one hand, either the left or the right.

Figure 1: A typical cryosurgical unit

1. Probe
2. Trigger
3. Handle grip (fiberglass)
4. Yoke
5. Inlet of gas from cylinder
6. Tightening knob
7. Pressure gauge showing cylinder pressure
8. Silencer (outlet)
9. Gas-conveying tube
10. Probe tip

- o The trigger mechanism unit should be made of rigid plastic, of a type and grade that will insulate the hand of the user while providing durability.
- o The hand unit shall permit the removal and attachment of the cryotip and/or the cryoshaft to facilitate cleaning.
- A hose assembly attaching the hand unit to a connector/pressure gauge assembly that connects to the high-pressure gas cylinder. The hose assembly comprises:
 - o A high-pressure hose to conduct the gas to the hand unit and a return hose to carry the waste gas back to the pressure gauge assembly to be vented (venting of the gas within the handset is not acceptable).
 - o The high-pressure hose, as required by ASTM F 882 – 84 (Reapproved 2002) *Standard Performance and Safety Specification for Cryosurgical Medical Instruments*⁵, shall be rated for a pressure that is at least twice the maximum gas cylinder pressure (ca. 2000 psi)
- o Ideally the hose will comply with the requirements specified in ISO 21969 (2009) *High-pressure flexible connections for use with medical gas systems*⁶.
- o A minimum hose assembly length of 150 cm is recommended to allow for the distance between the patient and the gas cylinder and sufficient free movement of the clinician while operating the device.
- o The hose is constructed with flexible plastic or rubber suitable for use with pressurized carbon dioxide or nitrous oxide.
- A connector/pressure gauge assembly that connects to the gas cylinder with the following features:
 - o A gas connector to permit the cryosurgical system to connect to the compressed gas cylinder. The connector is made of metal and should be appropriate for use with pressurized gases, specifically with carbon dioxide and nitrous oxide. Multiple types of connectors are available and compressed gas cylinder valves vary from country to country. It is essential that the proper

⁵ ASTM standards can be purchased online from the American Society for Standards and Testing at www.astm.org

⁶ ISO Standards can be purchased online from the International Organization for Standardization Store (www.iso.org/iso/store.htm) and most National Standards Bodies

connector is used with the compressed gas cylinder valve. More information on gas fittings and gas supplies are given in Chapter 2.

- o A pressure gauge to indicate the pressure within the system. The gauge may be colour coded to indicate the safe working pressure range for the device.
- o A pressure relief valve designed to protect the device, the user and the patient from potentially excessive tank pressure. Typically the valve should have an internal rupture disk which bursts at a set pressure, preventing the device from becoming over-pressurized. The pressure relief valve should be designed to rupture if the maximum pressure rating of the pressure gauge, the hose assembly, or the trigger mechanism is reached.
- o An exhaust port to which a hose can be connected to vent the exhaust to a place with adequate air circulation.
- o Optionally the equipment may be fitted with a pressure regulator to maintain a relatively constant pressure within the unit.
- o Preferably a silencer unit to reduce noise levels.
- o Active defrosting mechanisms may or may not be incorporated into the operation of the unit. Both active and passive defrost systems are acceptable for the treatment of precancerous cervical lesions. If an active defrosting option is included, it will be integrated into the trigger function or the hand unit to facilitate single handed operation of the equipment.
- o Optionally the equipment may be fitted with temperature sensors to indicate the probe temperature and a timer to indicate the duration of tissue exposure.

1.4 Cryotips

The cryotip will be removable to allow interchangeable tips to be used and to facilitate cleaning and disinfection after use. The cryotips may attach directly to the probe shaft or be integral to the probe shaft, in which case the

probe shaft shall be removable at its base from the hand unit.

The cryotip shall be made from surgical-grade materials or the manufacturers shall provide evidence that the materials used for the cryotips have been assessed for cytotoxicity according to ISO 10993-5 (2009), *Biological evaluation of medical devices – Part 5: Tests for in vitro cytotoxicity*, and for irritation and sensitization potential according to ISO 10993-10 (2010), *Biological evaluation of medical devices – Part 10: Tests for irritation and skin sensitization*. Cryotips with a well-established history of safe use are acceptable.

The cryotip shall be made from materials capable of withstanding routine sterilization by autoclave or disinfection with hospital disinfectants, including bleach solutions or any other disinfectant for surgical instruments.

The surface of the cryotip that contacts the cervix should be smooth with no sharp edges.

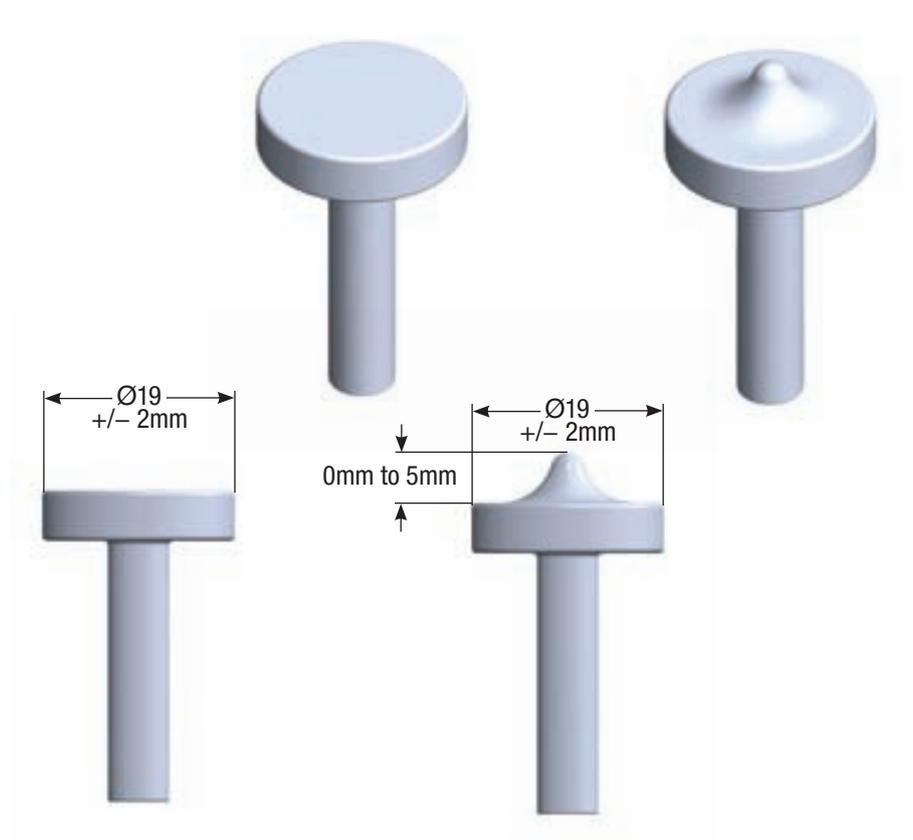
Only cryotips conforming to the following requirements should be used for the treatment of precancerous cervical lesions:

- The cryotips shall be of closed design. Open cryotips apply the cryogen directly to the target tissue and must not be used for treating cervical lesions because of the risk of damage to surrounding healthy tissue.
- The cryotips shall be rounded in shape and should be (19 +/- 2) mm in diameter (as shown in Figure 2).
- The surface that contacts the tissue should be either flat or with a cone extrusion (nipple shaped), not exceeding 5 mm (conical cryotips with extended nipple lengths shall not be used for treating precancerous cervical lesions)

1.5 Cryoshaft

The cryoshaft is made from materials capable of withstanding routine sterilization by autoclave or disinfection with hospital disinfectants, including bleach solutions or any

Figure 2: Illustration of dimensions of cryotips suggested for cryosurgical treatment of precancerous cervical lesions



other disinfectant for surgical instruments. Manufacturers should include information on disinfectants that can be used with the shafts and warn about any that can cause damage. With some designs of equipment it may not be possible to detach the cry shaft for sterilization. In such cases the manufacturers' procedures for disinfection should be followed.

The overall length of the cry shaft and crytip assembly should be between 170 and 200 mm. The cry shaft should not freeze during normal use; its outer surface should be insulated to prevent accidental freezing of any tissue that it touches.

The cry shaft should be rigid so that it does not flex during normal use.

The crytip should provide safe and consistent delivery of gas to the tip as well as gas exhaust back through the interior body of the tube.

1.6 Performance and safety standards

The cryosurgical equipment is capable of reaching and maintaining a cryotip temperature below -20°C and preferably below -50°C .

Ideally the cryosurgical system should conform to an appropriate national standard such as ASTM F882-84 (Reapproved 2002), *Standard Performance and Safety Specification for Cryosurgical Medical Instruments*. All high-pressure gas fittings incorporated into the cryosurgical unit should comply with regulations for compressed gas fittings in the country where the equipment is manufactured.

1.7 Regulatory status of cryosurgical equipment

In the US cryosurgical equipment is regulated as a Class II medical device. Before being

placed on the US market a 510(k) premarket notification has to be submitted to the Food and Drug Administration (FDA) providing information on the safety and effectiveness of the equipment. Manufacturers are required to demonstrate equivalence to a device that was on the US market prior to the introduction of the regulations (i.e. before May 28, 1976) or a device that has been shown to be substantially equivalent to such a device through a previous 510(k) submission. The previously-marketed device is known as the predicate device.

In Europe cryosurgical equipment falls into Class IIa according to classification rule 9 of the European Medical Device Directive (93/42/EEC as amended). Class IIa devices require prior clearance before being placed on the market in Europe by a Notified Body. Once the equipment is cleared for marketing the manufacturer must affix a CE Mark to the device to demonstrate that the product complies with the essential requirements of the directive. If the cryosurgical equipment includes any electrical components then the equipment may also be required to comply with other European regulations relating to the safety and compatibility of electrical equipment.

The regulation of medical devices in other countries and regions tends to vary considerably. Most low-resource countries have very limited, if any, regulation of most medical devices. It is therefore unlikely that product registration for cryosurgical equipment will be required in most low-resource countries but the national regulatory authority may insist on the product having US FDA 510(k) and/or European CE Mark clearance. National regulatory authorities may also require a certificate of free sale for the product in the country of manufacture and may want to review the documents submitted in support of 510(k) or CE mark approval.

A key stage in the procurement or purchase of cryosurgical equipment therefore is an assessment of local regulatory requirements, if any, in the recipient country or countries. Once the

assessment has been completed the procuring or purchasing agency can make certain that any local requirements are complied with. The following general rules are recommended when procuring or purchasing cryosurgical equipment:

- confirm with the national regulatory authorities whether there are any local regulatory or registration requirements for cryosurgical equipment;
- source equipment that has US FDA 510(k) and/or European CE Mark clearance;
- ensure that equipment which is not manufactured or distributed in the US or Europe, and does not have 510(k) or CE Mark clearance, has appropriate regulatory approval in the country of manufacture;
- ensure, where applicable, that the equipment manufacturer has the appropriate export licences issued in the country of manufacture for the equipment;
- ensure that the equipment manufacturers are prepared to supply any necessary documentation that may be required for local regulatory review in the recipient countries, including certificates of free sale.

1.8 Gas cylinder connector

The connector between the gas cylinder valve and the cryosurgical unit is an integral part of the cryosurgical unit. The connector will be specified when the equipment is purchased and must be compatible with the cylinder valve fitment available in the country where the equipment is to be used. Further advice on gas cylinders and gas connectors is given in Chapter 2, including a list of some of the most common fitments.

Gas cylinder fitments are specific to the type and grade of gas being used as well as the cylinder size. It is essential to determine the type of fitments available in-country before ordering cryosurgical equipment.

Some manufacturers provide an empty gas cylinder with the equipment. In such cases it is essential to confirm that the local gas supplier

has the correct fittings to be able to refill the cylinder prior to purchase. It is also essential to confirm that the supplied cylinder is of adequate capacity for treating cervical lesions (for further information on gas cylinder fittings and cylinder capacity, refer to Chapter 2).

1.9 Gas cylinders

A full review of gas supplies for cryosurgical equipment has been completed separately. This includes advice on the selection, procurement, storage, and handling of the gas cylinders (see Chapters 2 and 3).

1.10 Spare parts

Essential spare parts such as the hose assembly, cryotips, cryoshafes, O-ring, and sealing washers should be purchased from the original equipment manufacturer. Manufacturers should provide a referenced list of spare parts to facilitate ordering.

Chapter 2.

Advice and guidance regarding gas supplies for cryosurgical treatment of precancerous cervical lesions

2.1 Background

Cryosurgical equipment suitable for the in-clinic treatment of precancerous cervical lesions normally operates from a high-pressure gas cylinder. The most commonly-used gases are carbon dioxide and nitrous oxide. The probe tip is cooled by expansion of the gas through a nozzle, causing cooling by the Joule-Thomson effect. Both nitrous oxide and carbon dioxide have high Joule-Thomson coefficients, making them good gases for this application. Sourcing an appropriate supply of compressed gas can be problematic, especially in low-resource settings. This document provides advice and guidance to procurers and users of cryosurgical equipment in low-resource countries on obtaining, storing, and using suitable gases.

2.2 Gas quality

Gases are available in many different “grades”, including medical, food, industrial, ultrapure, and spectroscopic. Different manufacturers and/or distributors may use different designations for some of these grades.

Medical-grade gases are of very high quality and by necessity are free of any potentially problematic impurities. They are also more expensive than other grades.

- Although with the types of cryosurgical equipment that are suitable for treatment of cervical lesions there is no direct contact between the gas and the patient, it is nevertheless recommended that medical-grade gas is used if available and affordable. This is to reduce the risk of equipment blockages due to impurities such as moisture or particulate material in the gas.

Ideally medical-grade gases should be used, but if these are not available locally then food, beverage (for carbon dioxide), or equivalent grades can be considered. Use of “industrial”-

grade gas is discouraged. Gases should never be mixed, nor should any other gas than that specified by the equipment manufacturer be used.

The type of connector between the cylinder valve (which is part of the gas tank and supplied by the distributor) and the device not only depends on the type of gas, but also the grade of gas. It may not be possible therefore to switch between different grades of gas without also changing the fitting on the device. Again this reinforces the need to check the local availability of gas supplies before purchasing cryosurgical equipment.

2.3 Units used for gas pressure

Different units for pressure are in common use. The official SI (*Système international d’unités*) derived unit for pressure is the Pascal (Pa) but, to avoid excessively large numbers, it is normally more convenient to use the kilo Pascal (kPa) for gas pressures. A pressure of one Pa is equivalent to one Newton (a measure of force) per square metre. Other common units for pressure include pounds per square inch (psi), atmospheres, bar, and Kg/cm². Depending on the country, the most commonly used units are the bar, psi and kPa. Average atmospheric pressure at sea level is 101.325 kPa or 14.7 psi. A bar is defined as 100 kPa and is approximately equal to one atmosphere. Gas pressures in carbon dioxide and nitrous oxide cylinders are typically in the region of 800 to 1000 psi. Table 2 below compares the values for a pressure of 1.00 bar in the different units that are commonly used.

The gauges used on cryosurgical equipment are commonly colour coded to indicate the acceptable operational range. Red indicates that the gas pressure is too high, green that it is within the acceptable operational range, and yellow that it is too low.

Table 2: Values of 1 Bar of pressure in commonly-used units

Bar	kPa	psi	Kg/cm ²	Atmosphere (Std)
1.00	100	14.503773773	1.019716213	0.986923267

2.4 Properties of compressed gases

The properties of compressed gases and the requirements for their safe transport and storage can be confusing and difficult to understand. Different standards, regulations, and requirements apply to gases and gas cylinders depending upon country, region, and application. Some gases turn into liquids when compressed and are stored in the tank in liquid form. Others remain as gases even under very high pressures. If the gas in the cylinder is liquefied, then there are important implications for the storage, handling, and use of the gas which are discussed later in this document. All gases under pressure are potentially hazardous. When dealing with compressed gases it is therefore essential to understand the basic principles behind the purchasing, storage, and use of gases and gas cylinders.

An important concept in understanding the behaviour of gases under pressure is the “critical point”. The critical point is the combination of temperature and pressure at which separate liquid and gas or vapour phases effectively cease to exist. Above the critical temperature it is not possible to cause the gas to liquefy no matter how high a pressure is applied to it. In this state the gas is known as supercritical. The pressure required to cause a gas to liquefy at the critical temperature is known as the critical pressure. At temperatures below the critical temperature the gas can be liquefied if sufficient pressure is applied. This is why some gases liquefy at normal ambient temperatures and others do not.

Both carbon dioxide and nitrous oxide have critical temperatures that are a little higher than room temperature. For carbon dioxide the critical temperature is 31.2 °C and the critical

pressure is 73.8 bar (1,070.1 psi). For nitrous oxide the critical temperature is 36.4 °C and the critical pressure is 72.45 bar (1,050.8 psi). At normal room temperatures, therefore, both gases will liquefy at the pressures typically used in high-pressure cylinders. Carbon dioxide and nitrous oxide cylinders can contain both liquefied gas and gas vapour. This has a number of implications for the use of these gas cylinders.

1. **The pressure within the cylinders will remain largely constant as the gas is used until all the liquid is gone, at which point the gas pressure will start to drop.** The gas pressure may also drop during use as the cylinder is approaching empty because the rate of evaporation of the liquid can no longer keep the pressure constant. However, once the treatment is stopped, the pressure may recover. The pressure gauge cannot therefore be relied upon to indicate the amount of gas remaining in the cylinder. **If the gas pressure in the cylinder drops during use and then recovers, this should be taken as a warning that the cylinder is approaching empty.**
2. **The vapour pressure of the liquid, and therefore the pressure in the cylinder, will depend on temperature to a much greater extent than for cylinders containing compressed gases only (i.e. no liquid).** At typical storage temperatures in the range 20 °C to 30 °C, the pressure in a carbon dioxide cylinder can vary between approximately 850 psi and 1040 psi. For a nitrous oxide cylinder the pressure can vary between 734 psi and 916 psi. If carbon dioxide and nitrous oxide cylinders are stored in high temperature conditions (i.e. above 30 °C) the pressure may become too

high for use with some types of cryosurgical equipment until the cylinder has had time to cool to below 30 °C.

- 3. The cylinders must be standing upright in order to deliver gas. If they are used on their side then liquid or a mixture of gas and liquid will be forced into the equipment.** Cylinders may be stored upright or on their side, but before use they must be stood upright.

- **Some cylinders are fitted with a dip tube or siphon. These cylinders are intended to deliver liquid, not gas.** Some manufacturers mark siphon cylinders with a white stripe running along the length of the cylinder. If there is any doubt about whether a cylinder contains a siphon tube the supplier should be consulted. **Unless it is specifically stated for a specific piece of equipment that a siphon cylinder should be used, then never use a cylinder with a dip tube or siphon. Doing so could cause damage to the equipment leading to leaks, possible cold burns to the user, and even the risk of an explosion.**

As gas is drawn from a cylinder containing a liquefied gas, some of the liquid evaporates in order to maintain the constant pressure. This has a cooling effect. If gas withdrawal is rapid this can cause a sufficient drop in temperature for moisture to condense and even for frost to appear on the outside of the cylinder.

- **If for any reason there is a rapid discharge of gas, for example if a valve leaks or a hose bursts, the valve itself can become very cold and there is a risk of frostbite if the valve is touched.**

Gas suppliers always leave space in a cylinder containing liquefied gases, such as nitrous oxide and carbon dioxide, for expansion. Typically cylinders are only filled to about 75%

of the available volume in temperate climates and 67% in hot climates.

- **Overfilling could lead to excessive cylinder pressures during storage causing the pressure release valve to vent the entire contents of the cylinder. Always use a reputable gas supplier to reduce the risk of being supplied with overfilled cylinders.**

If the gas pressure in a cylinder is too high for the specific type of cryosurgical equipment being used, the excess pressure can be vented using the following procedure:

- Close the main cylinder valve.
- Ensure that the main cylinder valve opening is facing away from any people and slowly open the valve. Allow a small stream of gas to escape for 8–10 seconds.
- Close the main cylinder valve.
- Re-connect the cryosurgical system to the cylinder valve.
- Open the main cylinder valve again. If the pressure is still too high, repeat the procedure.

If a cylinder containing gas at an excessively high pressure is attached to some types of cryosurgical equipment, the equipment may be damaged. If at all possible try and check cylinder pressures before attaching the cryosurgical unit.

2.5 Gas cylinders

2.5.1 General

Pressures within carbon dioxide and nitrous oxide cylinders can be extremely high, typically up to just over 1,000 psi. Cylinders are normally constructed of carbon steel or aluminium. Cylinders containing high-pressure gas are potentially very dangerous. Additionally, using an incorrect gas can cause serious injury and death due to asphyxiation, poisoning, fire, and explosion. For these reasons most countries have stringent regulations controlling the transport, supply, and use of compressed gas cylinders.

- **Find out about the regulations regarding transport, supply, and use of compressed gas cylinders in your country.**

Depending upon local or regional regulations, the cylinders have to be tested periodically to make certain that they can withstand the high pressures reached in service. The frequency of testing is determined by local regulations in most countries. In general a hydraulic pressure test is required every five to ten years depending upon the type of gas and local regulations. All cylinders should carry an indication of when they were last tested and when a re-test is required, although the code system used may not be obvious. If there is any doubt about the age or condition of a cylinder, consult with the gas supplier to determine when the cylinder was last tested and cleaned.

It is essential that the gas suppliers' recommendations relating to the safe transport, storage, and use of the cylinders are followed. Cylinders must be restrained by suitable chains or holders to prevent them falling over, both in storage and in use.

- **If a cylinder falls over and the valve is damaged or broken, it can turn the cylinder into a dangerous projectile causing extensive damage, serious injury, and even death. Some guidelines on handling cylinders are included at the end of this chapter.**

2.5.2 Identification of gas cylinders

To assist in the identification of gases, cylinders are usually colour-coded. Unfortunately there are different colour-coding systems in operation depending upon the country, the standards being used, and even the supplier of the gas. In some countries the colour code system may not even be followed.

- **Find out about the colour coding of gas cylinders used in your country.**

Colour coding within the European Union is regulated under European Standard EN 1089-3⁷, *Transportable gas cylinders. Gas cylinder identification (excluding LPG)*. This standard specifies colour coding for all types of gas cylinders. Colour coding can be related to the hazard properties of the gas or by specific gas contained in the cylinder. Carbon dioxide is indicated by a dusty grey on the cylinder and nitrous oxide by dark blue. Different countries use different colour-coding schemes, although attempts to standardize colours are being made. The colour coding of medical gases is covered by an international standard, ISO 32 (1977), *Gas cylinders for medical use - marking for identification of content*. This standard applies to medical gases only; not all countries use the standard.

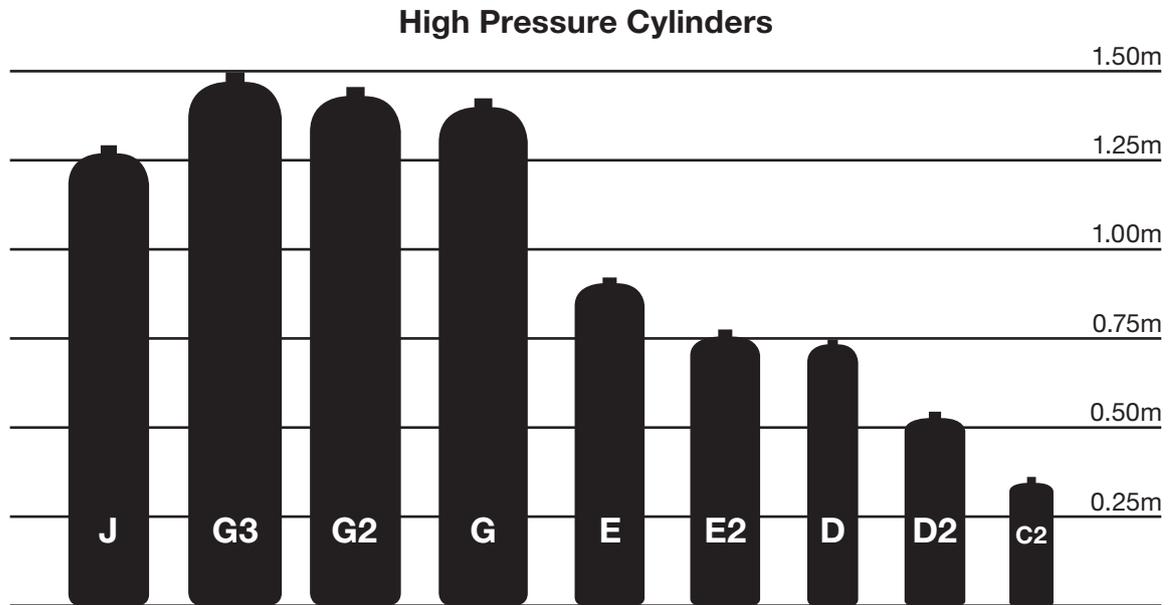
- **It is therefore essential to check the label of any gas cylinder carefully to make sure the correct gas and the correct grade are being used. If there is any doubt about the contents of a gas cylinder, then either contact the supplier for confirmation or do not use it!**

2.5.3 Cylinder sizes

Cylinders are available in a wide range of sizes (see Figure 3). The size of gas cylinders can be specified by a letter code, by the water capacity expressed in pounds, by internal volume, or by the volume of gas at normal pressure and temperature contained in the cylinder. Common sizes for European medical gas cylinders⁸ are size C containing 450 ml of gas, size D containing 900 ml of gas, size E containing 1800 ml of gas, size F containing 3600 ml of

⁷ European Standards are available for sale from European Committee for Standardization National Members, Affiliates, and Partner Standardization Bodies. See <http://www.cen.eu/cen/Products/Where/Pages/default.aspx> for more details.

⁸ BOC Healthcare, Priestley Road, Worsley, Manchester M28 2UT, UK.

Figure 3: Range of high pressure gas cylinder sizes

Source: OHYG BOC Gas Cylindersafety.pdf, p. 10

gas, size G containing 9000 ml of gas and size J containing 18 000 ml of gas.

- **The most common and useful sizes for cryosurgery are D and E.**

In the US, cylinder capacities are more commonly expressed in pounds (lbs). Commonly-used sizes for cryosurgery are 6 lbs and 20 lbs.

The number of cryosurgical sessions per cylinder will clearly depend upon the size of the cylinder, the type of equipment used, and the duration of the procedure. Wallach, in their sales literature, state that the LL100 Cryosurgical System using a 20 lb nitrous oxide cylinder should provide approximately 80 minutes of use. This would be sufficient for about 20 precancerous cervical lesion treatments. Practical experience, however, suggests that the number of treatments per 20 lb cylinder can vary widely. Contributors to this document commented that in some cases as few as two full treatment sessions have been possible with a 20 lb cylinder whereas in other

cases over 20 treatments were achieved. Local temperature conditions and the filling policies of local gas suppliers may have a significant impact on the number of treatments per cylinder.

Smaller cylinders may only provide sufficient gas for a few procedures and should only be used for emergencies. When deciding on a cylinder size it is essential to take into account such factors as costs, caseload, frequency of use, convenience of resupply, and local transport, storage and handling issues. As a general rule, it is best to opt for the largest cylinder size available subject to practical considerations relating to storage and handling on site.

2.5.4 Cylinder valves

All cylinders are fitted with a suitable valve to allow attachment to the equipment via an appropriate connector. To prevent the risk of an explosion, should a cylinder overheat during transport or storage, the valve assembly must have a pressure relief valve, normally in the form

of a rupture disc. These types of release valve do not reset; if for any reason the pressure limit is exceeded they will vent the entire contents of the cylinder.

- **For this reason transporting cylinders in enclosed vehicles can be extremely dangerous. If the rupture disc is activated then the entire contents of the cylinder will be vented into the vehicle.**

2.6 Connectors

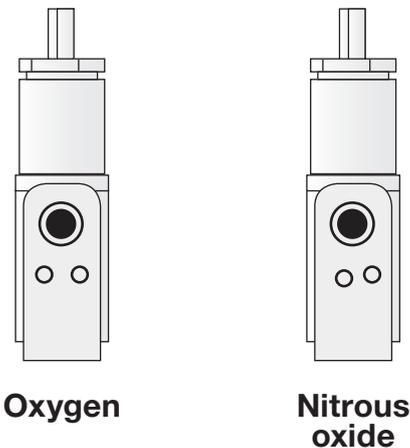
Because of the significant risks associated with using the wrong gas - which include poisoning, asphyxiation, fire, and explosion - different types of cylinder valve connectors are used to prevent the accidental connection of the wrong type of gas cylinder to any equipment. Connectors can be of different types and sizes. Some connectors screw onto the valve directly but the size and shape of the union and the type of thread used vary to prevent connecting the wrong type of connector.

For medical gases the use of pin-indexed yoke connectors is common, particularly for the smaller cylinders (see Figure 4 for examples). The location of the pins determines whether the connector will fit on a specific valve. Larger cylinders of medical-grade gases may use other types of connectors meeting American, British, or French specifications.

Some connectors rely upon a direct fit between the metal parts to form a seal, whereas others contain washers and/or O-rings. Many connectors are designed to be tightened by hand only, whereas others require the use of a spanner or wrench.

- **It is important to never over-tighten the connection, since this can weaken the joint and eventually lead to failure.**
- **O-rings and washers need to be inspected every time the cylinder is changed and replaced regularly.**

Figure 4: Examples of pin-indexed cylinder valves



Pin Indexed Cylinder Valves

Source: OHYG BOC Gas Cylindersafety.pdf, p. 10

- **Never apply any kind of lubricant to the thread or the connected thread; with oxidizing gases this could lead to an explosion.**
- **Do not use Teflon (PTFE) tape to seal the connector to the cylinder valve unless this is a specific requirement for the type of connector used. Most connectors do not need tape or any kind of lubricant.**
- **Open the cylinder valve slowly. Rapidly opening the valve can damage equipment attached to the cylinder and can cause the discharged gas to re-liquefy. This liquid can cause cold burns if in contact with the skin.**

Unfortunately, different specifications and standards for connectors are in use around the world. The type of fitting can vary depending on the intended use of the gas and the size of the cylinder. In the US the regulation of the connector is governed by Compressed Gas Association (CGA). For example, carbon

dioxide connections in the US use CGA type320 connectors (applicable for pressures up to 3000 psi). In Europe, Africa, and much of Australia and New Zealand the connectors comply with British Standard BS431 No.8 (BS 431 is interchangeable with European equivalents DIN477 No.6, SN219505 type 7, French NFE29650 type C, and Australian AS2473 type 30). Similar differences apply to nitrous oxide connectors. For example, BS341 type 13 applies to larger cylinders supplied in the UK, whereas pin-index yoke type connectors apply to smaller D and E size cylinders. In the US CGA326 threaded connections and CGA910 yoke connections can be used, but for ultra-high purity nitrous oxide, CGA712 is used. Further information on gas fittings, cylinders, and suppliers by country is given in Annex 5.

2.6.1 Specifying connector requirements

Some suppliers of cryosurgical equipment provide a complete package including an empty gas cylinder, whereas others do not. Even in those cases where a cylinder is supplied, it is necessary to confirm that the cylinder can be refilled locally. If not, it may be necessary to obtain the cylinder from a local supplier and ensure that the equipment manufacturer supplies an appropriate connector with the equipment.

- **Where a cylinder has to be obtained locally, it is essential to confirm that the cylinder valve fitting is compatible with the connector supplied by the cryosurgical equipment manufacturer.**
- **The recommended procedure is to identify which size of cylinder and which type of fitting can be obtained locally and to provide detailed specification to the cryosurgical equipment manufacturer.**

Some cylinders are provided with non-removable valve shields or collars. These shields or collars may interfere with the cryosurgical device connector supplied by the equipment manufacturer.

- **It is essential therefore when conferring with gas suppliers to get a full specification of the cylinder including the dimensions of any fitted shield. A photograph would certainly help.**

In some circumstances it may be necessary to use an adaptor between the cylinder valve and the cryosurgical device but this should only be done as a last resort. Should it prove necessary, it is essential to check local regulations to determine whether it is permitted.

- **The fitting of any adaptors should only be carried out by individuals with the necessary skills and qualifications to undertake such work.**
- **Any adaptors should be selected with great care to make sure that they are safe to use with the gas in question, and the pressures involved.**
- **All materials must be compatible with the gas and all fittings compatible with the device and valve assembly.**

2.7 Gas cylinder maintenance

As already pointed out, the gas in a cylinder is under high pressure and extensive damage and injury can occur if a cylinder ruptures or bursts. It is essential that cylinders are managed carefully and not subjected to excessive heat, mechanical trauma, or misuse. All cylinders should be inspected carefully on receipt to make certain that they are not damaged in any way, and inspected periodically during use. Some degree of wear and tear can be expected - for example, the paint can become scuffed and scratched. But never use a cylinder that has dents, bulges, evidence of fire damage such as scorch marks, or significant signs of corrosion. Further advice on handling cylinders is given in Chapter 3.

2.8 Nitrous oxide

Nitrous oxide is available in various sizes of high pressure cylinders. The cylinders are either made from carbon steel or aluminium. Under pressure at room temperature (21°C) nitrous oxide becomes a liquid at 52.4 bar (760 psi). A high-pressure cylinder of nitrous oxide therefore contains both liquefied gas and vapour.

The smaller sizes of nitrous oxide cylinder intended for medical use are fitted with pin index yoke fittings. Larger sizes will be fitted with a BS341-Type 13 fitting or a CGA326 threaded connector. The cylinders should have a working pressure of at least 137 bar.

Nitrous oxide is an anaesthetic. It can cause asphyxiation in high concentrations and is a strong oxidizing agent, strongly supporting vigorous combustion even with materials that do not normally burn in air. Exposure to the gas causes short-term decreases in mental performance and can cause disorientation, sedation, headache, nausea, vomiting, dizziness and loss of coordination, audio and vision problems, and loss of manual dexterity. The effects are rapidly reversible, but long-term exposure can cause vitamin B12 deficiency (megaloblastic anaemia), agranulocytosis, numbness, reduced fertility, reproductive side-effects in pregnant females, and other harmful side-effects.

- **Misuse of nitrous oxide, including its recreational use, can be dangerous. Do not play with it.**
- **Cylinders must be stored and used in well-ventilated areas. Good ventilation is essential when**

performing cryosurgery in small rooms.

- **The average occupational exposure level should be maintained at less than 100 parts per million (ppm) over an 8 hour period and should ideally be below 25 ppm⁹.**
- **Nitrous oxide cylinders should not be stored or used in the presence of flammable materials and/or sources of ignition.**
- **Oil or grease must never be used on any connectors or valves.**
- **It is very important to check all connections and joints for leaks after turning on the cylinder valve. If any leaks are discovered replace the O-rings or washers in the joint. Spare O-rings and washers should be ordered with the equipment and a good stock maintained by ordering replacements in a timely manner.**
- **Do not try and cure leaks by excessive tightening of any joint. This could lead to strain and ultimately failure of the joint.**
- **All O-rings, washers and gaskets must be compatible with nitrous oxide.**
- **Only use components recommended by the equipment**

⁹ The long-term exposure limit (8-hour time-weighted average (TWA)) and workplace exposure limit recommended by the UK Health and Safety Executive in EH40/2005 (as consolidated with amendments 2007) is 100 ppm. The National Institute for Occupational Safety and Health (1992) recommended exposure limit for nitrous oxide is 25 ppm as a TWA for the duration of the exposure. The American Conference of Governmental Industrial Hygienists (1994) assigned nitrous oxide a threshold limit value of 50 ppm as a TWA for a normal 8-hour workday and a 40-hour workweek.

suppliers. Ethylene propylene diene monomer (EPDM) O-rings, washes and gaskets are, for example, recommended for use with nitrous oxide.

2.9 Carbon dioxide

Carbon dioxide is a colourless, odourless gas that can cause the nose to sting in high concentrations. It is asphyxiant and toxic in high concentrations. Exposure to carbon dioxide may cause increased respiration, headache, nausea, vomiting, mild narcotic effects, increased blood pressure, increased heart rate, and occasionally unconsciousness. It is slightly corrosive in the presence of moisture. The gas is not combustible and does not support combustion (it is used in fire extinguishers).

- **Carbon dioxide is heavier than air. It can therefore collect in ducts, drains, and low-lying areas. Entering a poorly-**

ventilated room in which carbon dioxide cylinders have been stored is therefore potentially hazardous.

As with nitrous oxide, carbon dioxide liquefies under pressures exceeding 73.8 bar at temperatures below 31.2 °C. The gas is available in a wide range of cylinder sizes. Cylinders may contain a dip tube or siphon designed to deliver liquid carbon dioxide rather than the gas.

- **It is very important to check any carbon dioxide cylinder to make certain that it does not contain a dip tube before connecting it to cryosurgical equipment. Cylinders containing a dip tube may be marked with a white stripe. If necessary check with the supplier of the cylinder.**
- **Carbon dioxide cylinders should be stored or used in a well-ventilated area.**
- **All O-rings, washers and gaskets must be compatible with the gas.**
- **Only use components recommended by the equipment suppliers. EPDM O-rings, washes and gaskets are recommended for use with carbon dioxide.**

Chapter 3.

Recommendations for handling gas cylinders¹⁰

3.1 Main hazards from gas cylinders

The main hazards from gas cylinders include:

- blast impact, including flying debris, from a gas cylinder explosion or rapid release of compressed gas (cylinder pressures can be as high as 300 bar);
- impact from parts of gas cylinders, regulators or valves that fail;
- contact with released gas or fluid which might be toxic or asphyxiating;
- fire resulting from the escape of flammable gases;
- impact from falling cylinders (they are very heavy – as much as 80 kg);
- manual handling injuries;
- cold and frost burns due to the rapid pressure loss or evaporation of liquid gas.

3.2 Main potential causes of gas cylinder accidents

The main potential causes of gas cylinder accidents include:

- inadequate training and supervision;
- poor installation;
- poor examination and maintenance;
- faulty equipment and/or design (e.g. badly fitted valves and regulators);
- poor handling or storage;
- inadequately-ventilated working conditions;
- incorrect filling procedure (only use reputable companies to refill cylinders);
- hidden damage.

3.3 Inspection and training

- All gas cylinders must be initially inspected by a competent person before they are put into service, to ensure they conform to the approved standards.

- All gas cylinders must be periodically examined at appropriate intervals to ensure that they remain safe while in service.
- Anyone who examines or uses a gas cylinder should be suitably trained and have the necessary skills to carry out the job safely. They should understand the risks associated with the gas cylinder and its contents.
- Users should be able to carry out an external visual inspection of the gas cylinder and any attachments (e.g. valves and regulators) to determine whether they are damaged. Visible indication of damage includes dents, bulges, or evidence of fire damage (scorch marks).
- Gas cylinder users should satisfy themselves that the cylinders have been properly tested by examining either the written certificate accompanying the gas cylinder or the stamp or mark of relevant inspection body on the gas cylinder itself. The level of control over the quality of cylinders varies from country to country. In some countries certificates may not be routinely available and cylinders may not be stamped or marked. Users should nevertheless take whatever steps they can to confirm with the suppliers that the cylinders are safe and have been subject to testing.
- Gas cylinders must be clearly marked to show what they contain and the hazards associated with their contents.

3.4 Handling and use

- Gas cylinders should always be used in a vertical position, unless specifically designed to be used otherwise.
- Gas cylinders should always be securely restrained to prevent them from falling over (for example attached to a wall by a chain or strap).
- Always double check that the cylinder/gas is the right one for the intended use.
- Do not remove or discard any batch labels fitted to the cylinder if present.
- Before connecting a gas cylinder to equipment or pipework, make sure that the

¹⁰ These recommendations are based on a number of documents. The key references used are cited in the list of reference documents listed at the end of this chapter.

regulators and pipework are suitable for the type of gas and pressure being used.

- Gas cylinders can be heavy and difficult to handle. Wear appropriate personal protective equipment (such as safety shoes, protective overalls, or gowns and protective gloves) when handling gas cylinders, and safety spectacles when using them.
- Carefully clean any connector with a clean, oil-free cloth before connecting the regulatory to the cylinder valve.
- Never use excessive force when connecting equipment to the cylinder.
- After connecting a cylinder, check for any leaks at the cylinder valve, regulator, hose, or any other location where there is potential for leakage to occur.
- Should a leak occur between the valve outlet and the connector or manifold yoke, depressurise and remove the fitting and fit an approved sealing washer. Reconnect the fitting to the valve with moderate force only, fitting a replacement regulator or manifold tail-pipe as required. If the leak persists, label the cylinder as leaking and return to the company. Sealing or jointing compounds must never be used to cure a leak.
- Do not use gas cylinders for any other purpose than the transport and storage of gas.
- Never drop, roll, or drag cylinders.
- Close the cylinder valve and replace dust caps, where provided, when a gas cylinder is not in use.
- Ensure that the valve is protected by a valve cap or collar that the valve has been designed to withstand impact if the cylinder is dropped.

3.5 Lifting and transport

- Avoid the need for manual handling of gas cylinders whenever possible, for example by using cylinder trolleys.
- Do not lift cylinders by their valves, shrouds or caps unless they have been designed and manufactured for this purpose.

- Gas cylinders should not be raised or lowered unless adequate precautions are taken to prevent them from falling.
- Fit suitable protective valve caps and covers to cylinders, when necessary, before transporting. This helps to prevent moisture and dirt from gathering in the valve of the cylinder, in addition to providing protection during transport.
- Securely stow gas cylinders to prevent them from moving or falling. This is normally in the vertical position, unless instructions for transport state otherwise.
- Avoid transport on vehicles where the load space is not separated from the driver's compartment.
- Disconnect devices and hoses from cylinders when not being used.

3.6 Storage

- Gas cylinders should not be stored for excessive periods of time. Only purchase sufficient quantities of gas to cover short-term needs.
- Rotate stocks of gas cylinders to ensure first in is first used.
- Store gas cylinder in a dry, safe place on a flat surface in the open air. If this is not reasonably practicable, store in an adequately-ventilated building or part of a building specifically designed for this purpose.
- Gas cylinders containing flammable gas should not be stored in part of a building used for other purposes.
- Protect gas cylinders from external heat sources that may adversely affect their mechanical integrity. This is particularly important in hot climates.
- Store gas cylinders at room temperature (i.e. between 20-30 °C [68 -86 °F]) and away from sunlight.
- Gas cylinders should be stored away from sources of ignition and other flammable materials.
- Warning notices prohibiting smoking and naked lights should be posted in the cylinder storage area.

- Do not store gas cylinders containing flammable gases with cylinders containing oxidizing gases such as oxygen and nitrous oxide.
- Avoid storing gas cylinders so that they stand or lie in water or other liquid.
- Ensure the valves on empty cylinders are closed to prevent contamination entering the cylinder.
- Store gas cylinders securely when they are not in use. They should be properly restrained, unless designed to be freestanding.
- Store cylinders where they are not vulnerable to hazards caused by impact (e.g. from vehicles).

3.7 Reference documents

Safe use of gas cylinders: Guidance issued by the Health and Safety Executive, Issue 1. London, Health and Safety Executive, June 2004. (www.hse.gov.uk)

Medical Gas Data Sheet: Medical nitrous oxide, Essential safety information. BOC Healthcare Customer Service Centre, Priestley Road, Worsley, Manchester M28 2UT, UK.

Medical Gas Data Sheet: Medical carbon dioxide, Essential safety information. BOC Healthcare Customer Service Centre, Priestley Road, Worsley, Manchester M28 2UT, UK.

McIntosh N, Blumenthal P, Blouse A, eds. *Cervical Cancer Prevention: Guidelines for low-resource settings.* Baltimore, MD, Jhpiego Corporation, July 2000.

Chapter 4. Procurement guidance

This chapter provides information on procurement planning for procuring cryosurgical devices. Prioritizing and planning procurement activities upfront will avoid missed schedule milestones, the procurement of poorly specified equipment, and poor vendor relationships. These problems can cause delays and budget overruns. These are general guidelines and should be used as a complementary resource to local procurement and other regulations.

Procurement is a sequential process that includes seven major, interdependent steps, shown in Figure 6. An efficient and effective procurement procedure will include:

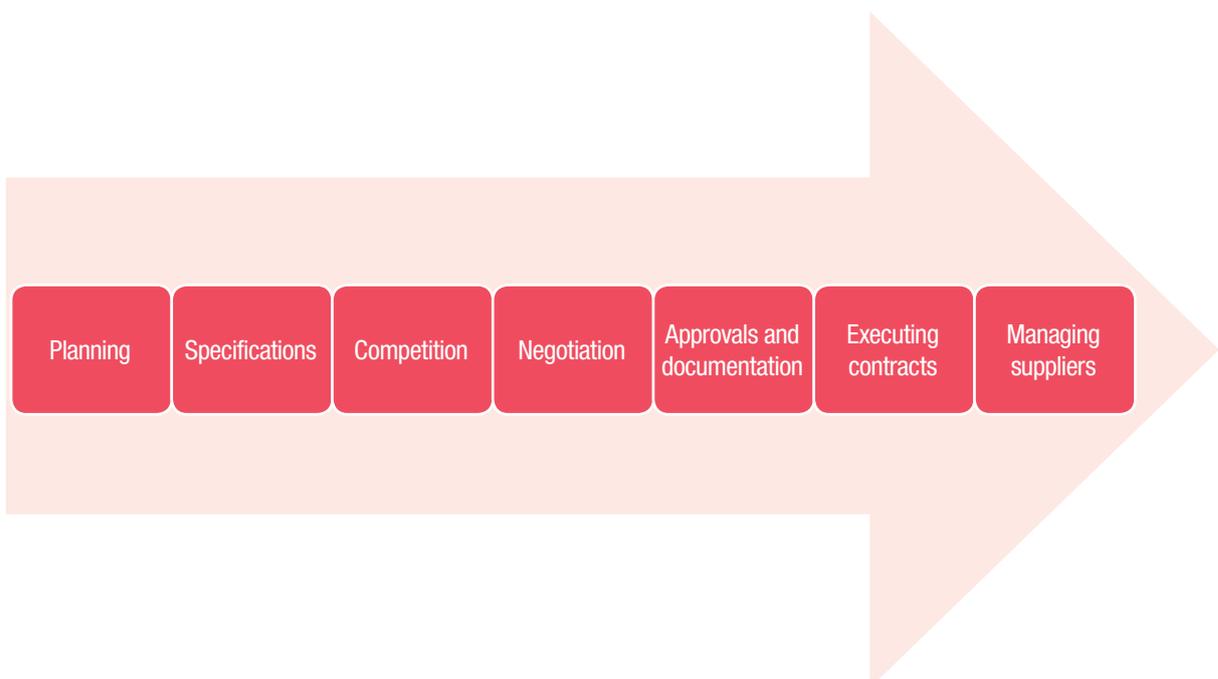
1. estimating the quantities of cryosurgical equipment, spare parts and gas supplies needed and their costs;
2. defining and verifying the fitness of specifications (i.e. the physical characteristics and performance of the cryosurgical equipment to be procured), taking into account any national regulatory or registration requirements;

3. preparing documents for competitive bidding and conducting the bidding process;
4. negotiating the details of the procurement with the selected supplier;
5. obtaining approvals and documentation;
6. completing the contract;
7. managing the supplier, delivery, and assuring quality.

4.1 Planning

Estimating the quantities of cryosurgical equipment, spare parts, and gas supplies needed and their associated costs is a critical first step to initiating procurement actions. This step will define the scope of the procurement. Procurement processes often escalate in formality and time required depending on value and complexity. The quantity estimate is used in confirming financial considerations, procurement methods, and shipping methods.

Figure 5: The stages of procurement



Consideration should be taken to calculate the number of facilities that will receive equipment and how many procedures per day will be performed. This information is important in determining the number of devices needed and the number of spare parts kits to include.

The required delivery date is also a critical piece of information that will inform when each procurement step needs to occur. The equipment should always arrive ahead of scheduled training with enough time to assemble and troubleshoot connections to gas. The procurement department will identify the amount of time needed for confirming specifications, conducting bidding, and other processes. Sufficient time should be allocated for the procurement process. Avoiding steps can lead to problems, ranging from bid protests to ordering incorrect or incomplete equipment. Transit time, customs processing, supplier manufacturing, contracting process, approval process, and negotiation should also be included in the timeline.

In some countries cryosurgical equipment may need to be approved and/or registered with the national regulatory authority as a medical device. A certificate of free sale in the country of manufacture may also be required for some recipient countries. In addition, some countries where the equipment is manufactured may require export certificates. Sufficient time and planning must be included to evaluate these regulatory needs and ensure that the manufacturers can supply all the documentation necessary to comply with local regulations where they exist. Failing to comply with this step can lead to the product being rejected or held in customs for long periods of time, and can also include severe penalties.

4.2 Specifications

Specifications define the physical characteristics and the performance standards of the equipment to be procured. Earlier chapters provide information and guidance that can

be adapted for procurement of cryosurgical equipment and gas supplies. Adaptations may be related to the gas supply. For example, if the gas tank connection requires a material of construction with a specific ASTM number because of in-country compatibility considerations, include the ASTM reference in the specifications. The cryosurgical equipment should conform to ASTM F882-84 (Reapproved 2002) *Standard Performance and Safety Specification for Cryosurgical Medical Instruments*, so this should also be specified in the request for a quote and carried on to the purchase order. If only one type of gas is realistically available, then the specification should indicate that only equipment compatible with the available gas will be considered. Care should be taken when ordering the devices to specify single- or dual-use gas. If either gas is acceptable, then the specifications should clearly state that options for each should be included in separate bids for CO₂ and N₂O devices (see Table 1).

Specifications include both minimum criteria for technical selection and optional considerations. If any area is considered optional, it must be clearly noted. Specifications must be clear and complete. When specifications are not complete, they often lead to offers that are difficult to compare and understand. In some cases, incomplete specifications can be considered an indication of a flawed procurement process and they leave the procurer open to a “protest” where suppliers can object to the final supplier selection. This creates delays and adds expense to the process. Specifications may also be used in pre- or post-shipment inspections (where applicable) and in overall acceptance of the final product.

4.3 Competition

Competitive procurement is an accepted method in the public sector for obtaining the best value for a quality device. In most countries, the procurement of cryosurgical equipment would be conducted along with the procurement of other medical and surgical

devices. The processes used generally adhere to strict national requirements for bidding, including strict deadlines, evaluation by a procurement committee, and sealed bids. Local procurement regulations generally dictate the selected process and procedure; however, if cryosurgical equipment is procured through more informal methods, including those available to some vertically managed programmes, the process should ensure diligence in planning, competition to ensure a range of options, specification development, and technical evaluation of offers.

4.3.1 Requesting quotations (invitation to bid)

The object of the Request for Quotation (RFQ) or Invitation to Bid is to solicit competitive offers that represent the best combination of technical and cost value. Typical orders for cryosurgical equipment will be under US\$ 100 000 and can be procured using the simplified RFQ process described below. Should the procurement value be in excess of US\$100 000 then a more formal process is generally required. The formal Invitation to Bid process requires an open invitation, a formal Request for Proposal document, and sealed bids, opened by a bid-opening committee on an established date and time.

The World Bank procurement guidelines offer an internationally accepted formal Invitation to Bid process¹¹.

4.3.2 Simplified request-for-quotation process

The RFQ communicates and establishes the technical requirements for the equipment, as well as all other criteria for awarding the final offer. It must be clear and structured, or resulting offers will lack the detail needed to evaluate the bids. At a minimum, the document should address equipment specifications,

quantities, delivery constraints, bid due date, and the procurer's standard contract terms and conditions.

All bids should be received sealed and only opened by the bid-opening committee at a specified time and date after the bid closing date and time. A bid analysis should be performed and documented. A template should be developed to indicate minimum technical and information requirements for the offers. This template should be developed at the same time as the RFQ and verified to ensure that the RFQ requests the required detail. Offers that do not meet the minimum requirements are rejected and only the remaining bids are reviewed for cost and other factors, such as supplier performance references, advantageous warranties, and other pre-established criteria. For a cryosurgical unit, it is appropriate to consider equipment cost, operating costs, delivery terms, warranty, and cost and availability of spare parts packages. Intangibles that would add to the assessment of each manufacturer, such as standardization with existing equipment, should also be included. All these variables should be put into a spreadsheet formatted for presentation to facilitate the analysis and support the final award.

4.4 Negotiation

Subject to local procurement regulations, negotiation can occur once the evaluation is complete and the supplier has been selected. The ability to negotiate on the content of an offer varies depending on local procurement regulations, but is generally not allowed until after an initial selection as been made. Terms and conditions, delivery, spare parts packages, and service and warranty period are typically the areas where negotiation is considered. In some case, price may also be considered negotiable. The contract should reflect all terms included in the RFQ (noting that the procurer's standard terms and conditions should have been included), as well as any specially negotiated terms. Negotiation does

¹¹ <http://web.worldbank.org/WBSITE/EXTERNAL/PROJECTS/PROCUREMENT/0,,contentMDK:20060840~menuPK:93977~pagePK:84269~piPK:60001558~theSitePK:84266~isCURL:Y,00.html>

not occur without some level of risk. Clear and transparent documentation of any negotiation proceedings must be kept. If the negotiation takes place in a verbal meeting, minutes must be prepared. If it occurs via email, records of all negotiations must be maintained. When the procurer initiates negotiation, it is assumed at that point that the supplier may also attempt to negotiate certain terms. This should be allowed. In any case where negotiation is performed, trained procurement negotiators, attorneys, or contract specialists should always be involved.

4.5 Approval and documentation

Before releasing a final contract, all elements of the procurement process must be documented and presented for approval to the appropriate body. In most cases, procurement authorities require a system of checks and balances whereby the parties creating technical specifications and conducting bid evaluations are separate from those who review and approve the transaction. This practice safeguards against internal bias towards certain manufacturers and also ensures neutrality in reviewing the key risk elements of entering into a contract. Those who review and authorize the final transaction should be individuals within the procurement department who have the training and authority to commit their organization. The procurement process should document all steps along the way in preparation for this final step. Failing to produce documentation for a specific step in a procurement process is often assumed to imply that the step did not take place or was insufficiently managed. Returning to earlier phases to rework an element that was not properly documented or managed can create problems ranging from delays to cancelling and re-starting the entire process. Organized documentation is important in defending the decisions of the procurement authority and protects the procurer's decision in the event of any liability.

4.6 Executing contracts

A purchase order (PO) or contract for goods and services is the final document that secures all terms and conditions of the transaction. The PO or contract is normally developed by the procurer and released to the supplier. It should represent all terms and conditions as agreed. The agreement would either be acceptance of all terms and conditions included in the RFQ, or all negotiated terms and conditions. When the PO is released, the supplier generally has a limited period (e.g. 3 working days) to accept or reject the purchase order. Rejection is rare and typically only occurs when the procurer does not accurately represent what has been agreed or adds significant terms that the supplier was not previously aware of.

Once the PO is accepted by the supplier, it represents a legally binding contract and governs the implementation of the transaction from that point forward. It is important to note that the PO governs the implementation of the transaction; however, the transaction must be actively managed to ensure compliance with the terms and conditions.

If a purchase order is altered in any way, a written amendment to the original purchase order must be created and signed by both procurer and supplier, and the documentation must be retained with other procurement documents related to the transaction. Once agreed to, any amendments are binding under the terms of the original purchase order.

4.7 Managing the supplier delivery and assuring quality

The procurement process should build in steps to assure that the equipment will be of appropriate quality and performance when it finally arrives. POs and contracts have terms that allow them to not accept equipment that fails to meet the specifications, but avoiding such a situation is critical to maintaining timelines and avoiding extra costs. It is good practice to follow up with the supplier in advance of ship-

ping to ensure the agreed-upon delivery dates will be met. This will allow the receiving organization to properly plan for receipt inspection.

When necessary, equipment can be inspected prior to shipment or upon arrival in a country. This is referred to as pre- or post-shipment inspection and is conducted based on a subset of the specifications. It has limitations, but can be an effective safeguard when needed. An example of a limitation is that an inspector can confirm that contents meet the descriptions of the equipment, but they cannot test it to ensure that it meets performance standards without a specific testing protocol.

Pre-shipment factory testing is one way that many organizations assure the quality of their equipment purchases, particularly if certain tests need special test equipment that the buyer does not possess. In these cases, documentation of the test results is provided. The results are either inspected by an official inspector, or by a competent authority within the procurement agency. Verification that the documents are correct and bone fide is generally part of compliance with current Good Manufacturing Practices (cGMP). If a manufacturer is cGMP certified, the documents can be reasonably expected to be accurate and bone fide. If not, the procurer may opt to visit the factory and witness the testing or accept the documentation of the testing at their own risk.

Inspection criteria should be carefully used and developed. Excessive criteria can add costs, delays, and confusion if they are not implemented by qualified staff.

It is important to perform a comprehensive post-delivery inspection of the equipment after it is delivered to the receiving site. The inspection, which should be done immediately the equipment arrives, should document any damage or non-conformance to specifications. It should be reported immediately to the supplier and remedies should be sought.

A post-delivery inspection is a comprehensive, final inspection of the purchased equipment. The objective of the post-delivery inspection is to find any missing components, damage, or malfunctions.

Preparation for the inspection is done by developing a checklist based on the purchase order specifications. Include the equipment's original specifications in the purchase agreement. The inspection/receipt report should be documented as part of the procurement for the transaction.

If damage or problems are discovered, and the supplier cannot arrange for on-site remedy or repairs, then the equipment should be sent back to the manufacturer. If the schedule cannot accommodate the time required for the reworking, then the procurement department and the vendor will need to negotiate financial reparations or replacement. Payment for the shipment should only be made after the shipment has passed all inspections.

It is also important to track supplier's schedule and quality performance over time. Poorly-performing suppliers should be advised that expectations of their performance have not been met. Performance levels can also become evaluation criteria when considering future business.

Procurement is a crucial process. It ensures good stewardship of funds and supports quality medical care when medical equipment or supplies are involved. An appropriate and well-managed procurement process can take time and resources. The consequences of a poorly-managed procurement process can be devastating to programmes, ranging from delays to irreplaceable losses of limited funding. Procurement professionals are trained to work in conjunction with legal, financial, and technical departments. They work to coordinate a process that protects public funds and ensures the best possible results for those ultimately seeking health services that depend on supplies and equipment.

Annex 1. Glossary of terms

Active defrost – a mechanism within some cryosystems that accelerates the return of the cryotip towards ambient temperature.

Cryotip – an interchangeable tip designed to fit a specific anatomical site (cervix) for the purpose of freezing the tissue. A closed cryotip will not vent gas or cryogen in the vicinity of the tissue. An open cryotip directly jets the gas or cryogen onto the tissue and is not appropriate for use in treating cervical lesions.

Compressed gas cylinder – a container that is specifically designed to store a gas or liquid under elevated pressure conditions.

Compressed gas cylinder valve – a device specifically designed to receive a connector to the cryosystem. It is pre-attached to a gas cylinder to allow for the proper and safe release of its contents.

Connector to the cryosystem – the fitting between the compressed gas cylinder valve that connects the tank to the cryosystem.

Connection adapter – an extension placed between the compressed gas cylinder valve and the connector to the cryosystem, which is used in cases where there is mismatch between the valve tip and connector to the cryosystem, including the valve being too short, the wrong threading etc.

Cryo-adhesion – cryotip attachment to target tissue.

Cryogen – a substance, such as compressed gas or liquid, used to obtain reduced temperatures. Cryogens are usually classed by their boiling points and their grade. The most common cryogens for precancerous cervical lesions and their respective boiling points are as follows:

Cryogen	Boiling Point at STP (°C)
Carbon Dioxide (CO ₂)	-78.6
Nitrous Oxide (N ₂ O)	-88.5

Cryonecrosis – destruction of tissue cells using cryogen (see clinical references for additional detail).

Cryoshaft – the component onto which the cryotip is attached. The cryoshaft may be detachable or fixed, and should be thermally insulated.

Cryosystem – collectively, all parts of system necessary to apply cryogen therapeutically, for the treatment of cervical precancer. It excludes the gas and its tank, the compressed gas cylinder valve, and the adaptor.

Defrost – the function of the cryosystem which allows the cryotip to return toward ambient temperature.

EPDM – ethylene propylene diene monomer rubber.

Exhaust hose – a hose that returns the exhaust gas from the cryogun to the regulator assembly for venting.

Exhaust port vent – the vent to which a tube can be attached to safely vent the exhaust gas from the room.

Gasket – a round, flat plastic or rubber ring (that looks like a washer) which is usually placed between the connector to the cryosystem and the compressed gas cylinder valve.

Handle – the part of the cryosystem that is gripped in the hand and that includes the trigger mechanism.

Hose assembly – polymer tubes that carry the cryogen from the regulator to the handle. In cryosystems, it is common to have an assembly in which there may be tubes inside a main hose.

Mechanical integrity – the ability of all components of a cryosystem to withstand the pressures and temperatures that may be encountered during use as recommended by the manufacturer.

Notified Body – in relation to medical devices, an organization authorized by a Competent

Authority of a European Member State to determine whether a medical device meets the essential requirements of the European Medical Device Directive.

O-ring – a ring of rubber or silicon usually inserted between the cryotip and the cryoshaft to ensure an effective seal to avoid leaking.

Passive defrost – a function of a cryosystem (without active defrost) to return towards ambient temperature. Passive defrost is typically a slower process of defrosting the cryotip than active defrost.

Regulator – a device for maintaining a constant gas pressure. Note that most cryosurgical devices are not equipped with a regulator.

Rupture disc – see safety valve.

Safety valve – a valve, usually a rupture disc, to release excessive pressure in the system. Can also be called a pressure relief valve.

Single-use disposable – any device which is designed to be discarded after one use.

Target tissue – the specific anatomical area of the cervix intended to be treated.

Thermal insulation – a material used to prevent unintended cryonecrosis, inflammatory responses, or cryo-adhesion to non-target tissues.

Thermocouple – a junction of two dissimilar metals that produce an output voltage proportional to the temperature of the junction. The output is directly correlated to the temperature to which the sensing junction is exposed.

Tractive force – the level of attraction between the cryotip and the target tissue during cryo-adhesion, i.e. when the tip freezes to the tissue.

Trigger mechanism – the mechanism that is activated (or squeezed, pressed, or pushed) to release the cryogen into the cryotip. Cryosystems may also include triggers for active defrosting.

US FDA – United States Food and Drug Administration, an agency within the U.S. Department of Health and Human Services that protects public health by assuring the safety, effectiveness, and security of human and veterinary drugs, vaccines and other biological products, medical devices, the food supply, cosmetics, dietary supplements, and products that give off radiation.

Washer – see gasket.

Annex 2. Technical Basis Paper: Cryosurgical equipment for the treatment of precancerous cervical lesions

A1 Introduction and scope

This technical basis paper reviews the types of cryosurgical equipment that are available and discusses some of the key issues in acquiring and using the equipment in low-resource countries. It is intended to summarize the technical discussions undertaken by the WHO Cryotherapy Technical Specification Working Group and provide background information supporting the recommendations made in the Cryotherapy Technical Specifications and Procurement Guidelines. It is not intended for circulation to users of the equipment, but to provide a record for future reference of the issues discussed and rationale for the recommendations made.

A1.1 Research methods

The paper is based on a literature search for information on cryosurgical equipment conducted online using the NML Gateway (a service of the US National Institutes of Health) which accesses multiple retrieval systems including MEDLINE/PubMed.

Information related to cryosurgical devices and equipment has also been collated from the following sources:

- The 2008 WHO/UNFPA/PATH Cryotherapy Market Survey.
- Bench testing of four cryosurgical devices with nitrous oxide and carbon dioxide in Peru in 2009.
- Discussion held by the Technical Specifications working group during the March 30-April 1, 2009: Building a consensus on approaches to improving cryotherapy service delivery to prevent cervical cancer.
- Meeting on Procurement of Cryotherapy Equipment for Cervical Cancer Prevention. September 23rd and 24th, 2010.

A1.2 Cryosurgical equipment

Cryosurgical equipment is available from a number of manufacturers, mainly US-based but with some types available from European and

Indian manufacturers. The equipment is used to treat a wide range of medical conditions in dermatology, ophthalmology, gynaecology, and other disciplines. Not all cryosurgical equipment is suitable for the treatment of precancerous cervical lesions.

Two main methods are used to cool the cryoprobe: the expansion of a compressed gas through a nozzle, causing cooling by the Joule-Thomson effect; and the use of cryogenic liquids such as liquid nitrogen. Because of the risk of damaging surrounding tissue, cryosurgical equipment based on cryogenic liquids is never used in the treatment of precancerous cervical lesions. Additionally, the availability, transport, delivery, storage, and handling of liquid nitrogen can be problematic in low-resource countries. For these reasons this paper only considers cryosurgical equipment that operates on compressed gases such as nitrous oxide and carbon dioxide.

Both nitrous oxide and carbon dioxide have high Joule-Thomson coefficients making them good gases for this purpose. Most cryosurgical equipment manufacturers offer the option of carbon dioxide or nitrous oxide. The choice of gas has to be made at the time of purchase of the equipment to ensure the proper fittings, and in some cases the appropriate device. In low-resource settings carbon dioxide is often cheaper and more readily available.

The recommended temperature most widely cited in the literature for treating precancerous cervical lesions is $-20\text{ }^{\circ}\text{C}$ but a review of tissue injury in cryosurgery by Gage and Baust¹² suggests that $-50\text{ }^{\circ}\text{C}$ is the appropriate temperature for ensuring destruction of cancerous tissue. Ideally therefore, the specification for any cryosurgical unit recommended for treating precancerous cervical lesions should indicate

¹² Gage A, Baust J. Mechanisms of tissue injury in cryosurgery. *Cryobiology*, 1998, 37.3:171–86.

that the equipment is capable of achieving tip temperatures of -50°C .

Examples of some of the main suppliers that have been identified through internet searches are given in Table A1.

A1.3 Description of a typical cryosurgical unit

A typical cryosurgical unit consists of a hand unit with a shaft to which detachable probe tips can be attached. The hand unit is fitted with one or more triggers and other controls to regulate the temperature and control the freezing/thaw cycle. It is designed such that the controls can be used with just one hand. Some models are fitted with temperature sensors to indicate

the probe temperature and a timer to indicate the duration of tissue exposure.

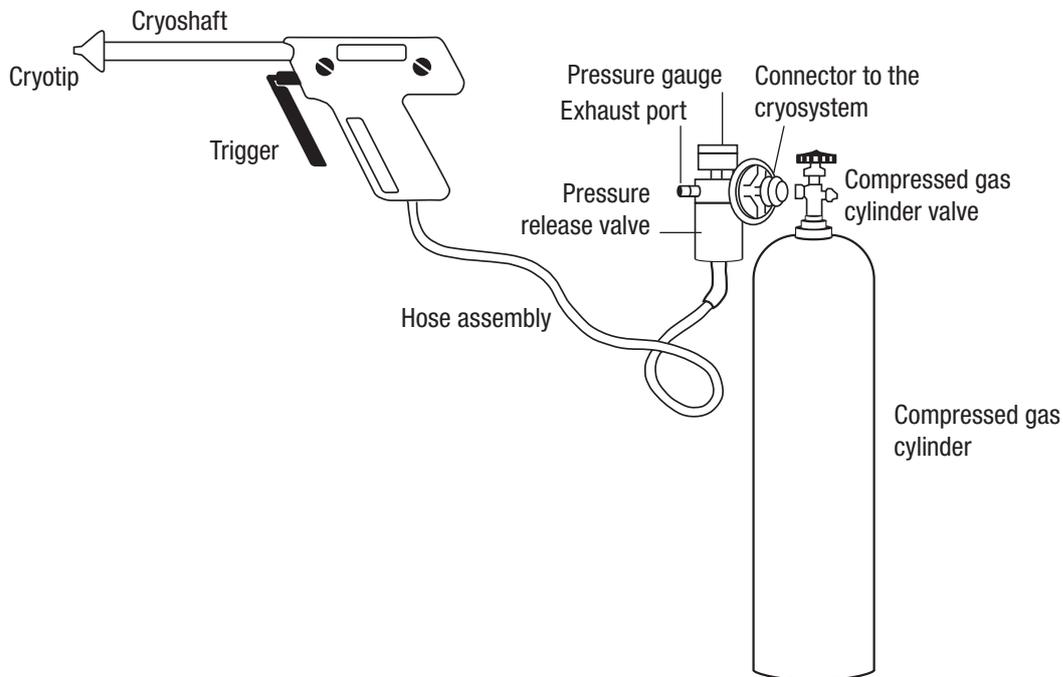
The hand unit is attached to a pressure gauge assembly that conducts the high pressure gas to the unit and returns waste gas to be vented.

A1.4 Cryotips

Most manufacturers offer a wide range of interchangeable cryosurgical probe tips (cryotips). These are interchangeable and can be cleaned and disinfected between patients. In some cases the cryotips can be changed without depressurising the system. Some cryotips can be autoclaved whereas others can only be disinfected by treatment with chemical disinfectants. The manufacturers' instruction must

Table A1: Suppliers of cryosurgical equipment suitable for cervical lesions

Company	Country	Models	Gas	Manufacturer Contact Details
Leisegang (Cooper-Surgical)	USA	LM-900 Cryosurgical	CO_2 or N_2O	www.coopersurgical.com +1 203 601 9818
Wallach	USA	LL100	N_2O only	www.wallachsurgical.com +1 203 799 2000
Wallach	USA	LLC02	CO_2 only	www.wallachsurgical.com +1 203 799 2000
Wallach	USA	WA1000B	CO_2 or N_2O	www.wallachsurgical.com +1 203 799 2000
Ascon Medical Instruments	India	Not stated	CO_2 or N_2O	www.asconmedical.com +91 44 22254420
Frigitronics (Cooper-Surgical)	USA	Surgical Plus CM-73	CO_2 or N_2O	www.coopersurgical.com +1 203 601 9818
MedGyn Products	USA	Cryotherapy System	CO_2 or N_2O	www.medgyn.com +1 630 627 4150
Basco India	India	Super Deluxe Silencer Gun Model: CRYO-004	N_2O	www.basconline.com +91 44 2371 5699
ERBE Elektromedizin	Germany	Erbokryo CA Erbokryo 12	CO_2 or N_2O	www.erbe-med.com +49 7071 755-0
Appasamy Assoc.	India	Cryo Super Model AA1 and AA2	CO_2 or N_2O	www.appasamy.com +91 44 32980153

Figure A1: A typical cryosurgical unit

be followed when determining the cleaning and disinfection cycle for any probe type.

Only closed cryotips can be used for treating cervical lesions. Open cryotips apply the cryogen directly to the target tissue and must not be used for treating cervical lesions because of the risk of damage to surrounding healthy tissue.

The cryotips are usually made from surgical-grade interchangeable metal fittings. Some designs are covered with a plastic sleeve which is removable for cleaning. Based on an assessment of the type and duration of exposure to the cryotips according to ISO 10993-1 (2009), *Biological evaluation of medical devices*, it is recommended that the cryotips should be assessed by the manufacturers for cytotoxicity, irritation, and sensitization potential. If medical-grade materials are used for the cryotips, then actual testing may not be necessary. Cryotips with a well-established history of safe use also do not need to be subjected to testing according to ISO 10993-1.

The cryotip must be removable to allow interchangeable tips to be used and to facilitate cleaning and disinfection after use. In some configurations, the cryotip attaches to the probe shaft with internally threaded surfaces inside the metal tube. Other configurations combine the probe shaft and the cryotip. These are detachable at the base of the probe. Both configurations provide the same intended result and there are no technical reasons to select one over the other, although detachable cryotips may be easier to sterilize by boiling or autoclaving.

Cryotips used for treating precancerous cervical lesions should be rounded in shape and be 19 mm in diameter \pm 2 mm. The surface that will come in contact with tissue should be either flat or with a cone extrusion (nipple shaped), but the protrusion should not exceed 5 mm. Both of these configurations meet the clinical recommendation criteria of covering 75% of the cervix. Conical cryotips with extended nipple lengths should never be used.

The surface of the cryotip should be smooth with no sharp edges. The material should withstand routine sterilization or disinfecting with hospital disinfectants. It is recommended that the manufacturers' recommendations for cleaning and disinfection are followed. Not all cryotips can be autoclaved or disinfected with some hospital disinfectants.

A1.5 Cryoshaft

The cryoshaft connects the cryotip to the trigger unit. It does not have a required minimum or maximum length but typically the overall length of the cryoshaft and cryotip assembly should be between 170 mm and 200 mm. The cryoshaft should not freeze during normal use; its outer surface should be insulated to prevent accidental freezing of any tissue that it touches. The cryoshaft should be rigid so that it does not flex during normal use. It should provide safe and consistent delivery of gas to the tip as well as gas exhaust back through the interior body of the tube.

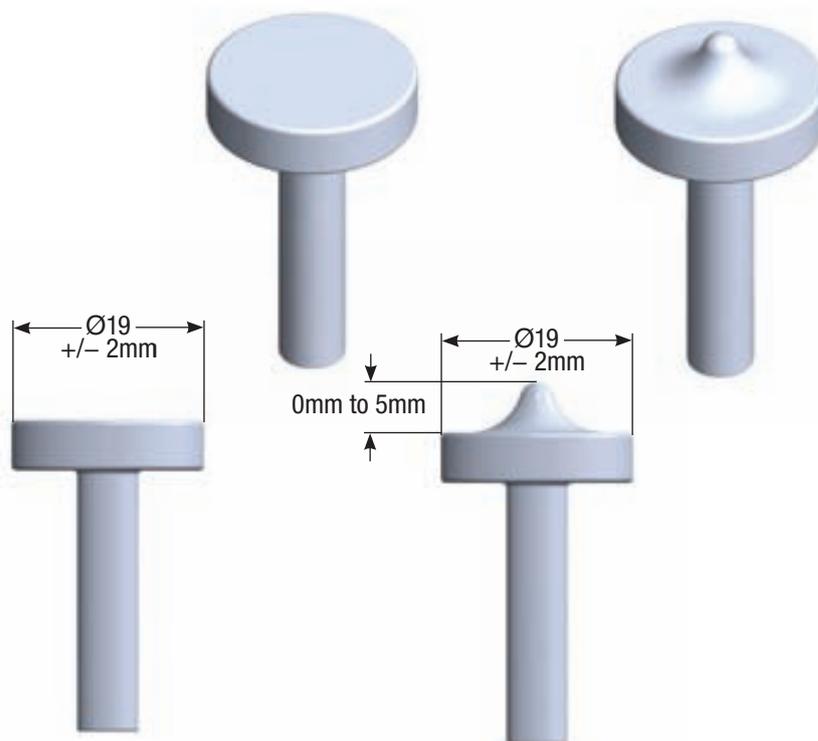
The materials used for its construction must be able to withstand routine sterilization or disinfecting with hospital disinfectants, including bleach dilutions or any other disinfectant for surgical instruments.

A1.6 Trigger mechanism

The hand unit should have an integrated trigger or other mechanism to activate the flow of gas. The trigger mechanism should be designed to give the user sensory feedback indicating whether the device is in the on or off position. There should be a latching or ratchet mechanism allowing the user to lock the trigger in the on position. The trigger must also have a release mechanism to unlock the trigger and return the device to the off position.

The trigger mechanism activates the internal valves and switches required to deliver the gas from the attached hose through the gas delivery tube to the cryotip and exhaust gas

Figure A2: Illustration of dimensions of cryotips suggested for cryosurgery of precancerous cervical lesions



back through the exhaust tube. The trigger mechanism unit should be made of rigid plastic, of a type and grade that will insulate the hand of the user while providing durability.

The material must withstand routine sterilization or disinfecting with hospital disinfectants, including bleach dilutions or any other disinfectant for surgical instruments. The handle should be of a design that allows the user to hold and control the device in one hand, either the left or the right.

Active defrosting mechanisms may or may not be incorporated into the operation of the unit. If an active defrosting option is included, it may be integrated into the trigger function or the handle. Both active and passive defrost systems are acceptable. Whatever system is used, it must be capable of being operated by one hand.

A1.7 Hose assembly

The hose assembly connects the trigger mechanism to the gas supply, both delivering the gas and venting the exhaust gas. The hose assembly should be of sufficient length for comfortable operation while the tank is appropriately secured to a nearby wall or safe portable stand. A minimum of 150 cm is recommended to allow for distance between the patient and the gas tank and sufficient free movement of the clinician while operating the device. The hose is constructed with flexible plastic, suitable for use with pressurized gas, and appropriate for use with carbon dioxide or nitrous oxide.

The hose connection should be integrated into the handle and not designed for removal by the user. The other end of the hose should securely connect to the pressure gauge. The hose assembly should be capable of being pressured to at least twice the maximum cylinder pressure¹³ (ca 2,000 psi). Ideally, hoses complying with the requirements specified

in ISO 21969 (2009) *High-pressure flexible connections for use with medical gas systems*, should be used.

Due to the constant flexing, pressure, and movement during use, the hose assembly should be checked periodically for signs of damage including leaks or cracks. If damaged, cracked or leaking, the hose assembly must be replaced with replacement part provided by the manufacturer. Most manufacturers supply a step-by-step instruction on how to replace the hose assembly.

A1.8 Pressure gauge

The pressure gauge is a visual indicator of the pressure in the tank and should clearly indicate whether the gas pressure is within the appropriate range (minimum to maximum) for the device to function properly. For many cryosurgical devices, the pressure gauges are colour-coded to indicate the safe operational range.

A1.9 Pressure relief valve

The pressure relief valve is designed to protect the device and the user from potential excessive tank pressure. It typically works by having an internal rupture disc which bursts at a set pressure, preventing the device from becoming over-pressurized. The pressure relief valve should be designed to rupture if the maximum pressure rating of the pressure gauge, the hose assembly, or the trigger mechanism is reached. Once triggered, the relief valve will completely empty the cylinder.

A1.10 Exhaust port

Since both carbon dioxide and nitrous oxide can be hazardous, cryosurgical units should have an exhaust port that allows the operator to attach a hose to vent the exhaust to a place with adequate air circulation.

A1.11 Gas connector

The gas connector connects the cryosurgical system to the compressed gas cylinder.

¹³ ASTM F 882 – 84 (Reapproved 2002), *Standard performance and safety specification for cryosurgical medical instruments*.

It should be made of metal and should be appropriate for use with pressurized gases, specifically with carbon dioxide and nitrous oxide. There are multiple types of connectors (compressed gas cylinder valves vary from country to country). It is essential that the proper connector is used with the compressed gas cylinder valve. More information on gas fittings and gas supplies are given later in this document and in the document on gas supplies.

A1.12 Performance and Safety Standards

Ideally cryosurgical systems should conform to appropriate standards such as F882-84 (reapproved 2002) *Standard Performance and Safety Specification for Cryosurgical Medical Instruments*. This specification covers standards a manufacturer must meet in the designing, manufacturing, testing, labelling, and documenting of cryosurgical medical instruments, but does not cover factors such as production methods, quality control techniques, manufacturer's lot release criteria, or clinical recommendations.

A1.13 Training

All equipment should be fit for the intended purpose of treating precancerous cervical lesions. Each unit should be accompanied by training materials specifying basic operation of all components, assembling the equipment, risks of use, and maintenance.

A1.14 Spare parts

It is imperative that spare parts such as the hose assembly, cryotips and cry shafts be purchased from the original equipment manufacturer. Due to varying design, replacement parts from other manufactures are not acceptable replacements. Similar comments apply to parts that require inspection and replacement on a regular basis. These include O-rings and sealing washers. A supply of these components should be purchased with and maintained with the equipment.

A2. Bench testing of cryosurgical devices and equipment

Bench testing was conducted in Peru using four different makes of cryosurgical devices and locally obtained nitrous oxide and medical- and industrial-grade carbon dioxide. The temperatures reached by each device when used with each gas were compared using a thermocouple to continuously monitor the temperature of the cryotip. Comparisons across the devices were based on the mean and lowest temperatures reached. The study found that all of the devices tested reached temperatures below $-50\text{ }^{\circ}\text{C}$ with nitrous oxide, the temperature considered most appropriate for treating precancerous cervical lesions. However, 35% of the Ascon devices and 15% of the Wallach devices tested with nitrous oxide did not reach $-50\text{ }^{\circ}\text{C}$. Two of the four devices (Ascon and Wallach) did not reach mean temperatures colder than $-50\text{ }^{\circ}\text{C}$ with carbon dioxide, irrespective of grade.

One-way analysis of variance identified the device as the dominant factor determining the differences in temperature, whereas the gas was not a significant determinant of temperature reached. The study concluded that both nitrous oxide and medical- and industrial-grade carbon dioxide reach appropriate freezing temperatures with some cryosurgical devices and that performance of some cryosurgical devices is suboptimal. Given that carbon dioxide is likely to be the preferred gas in low-resource countries since it is generally more readily available and cheaper, the outcome of this study suggest that the choice of a device that can reach the recommended temperature of $-50\text{ }^{\circ}\text{C}$ is important.

A3. Recommendations on gas supplies

A full review of gas supplies for cryosurgical equipment has been completed separately. This includes advice on the selection, procurement, storage and handling of the gas cylinders (See Chapter 2 and 3). Both carbon dioxide and nitrous oxide are liquid at the typical pressures

found in commercial gas cylinders. This significantly increases the capacity of gas that can be stored in an equivalent-sized cylinder compared to the amount of a gas that does not liquefy under normal cylinder pressure.

Carbon dioxide and nitrous oxide can be obtained in a number of different purity grades and in a wide variety of cylinder sizes. In general, the purer the grade the less likely is the risk of the cryosurgical equipment becoming clogged during use. For this reason medical-grade gases are preferred, with food/beverage grades being acceptable as an alternative.

Cylinders are available in a wide range of sizes. The size of gas cylinders can be specified by a letter code, by the water capacity expressed in pounds, by internal volume, or by the volume of gas at normal pressure and temperature contained in the cylinder. Common sizes for European medical gas cylinders¹⁴ are size C containing 450 ml of gas, size D containing 900 ml of gas, size E containing 1800 ml of gas, size F containing 3600 ml of gas, size G containing 9000ml of gas and size J containing 18 000 ml of gas. In the US cylinder capacities are more commonly expressed in pounds (lbs). Commonly used sizes for cryosurgery are 6 lbs and 20 lbs.

The number of cryosurgical sessions per cylinder will clearly depend upon the size of the cylinder, the type of equipment used and the duration of the procedure. Wallach, in their sales literature, state that the LL100 Cryosurgical System using a 20 lb nitrous oxide cylinder should provide approximately 80 minutes of use, i.e. sufficient for about 20 precancerous cervical lesion treatments. Practical experience, however, suggests that the number of treatments per 20 lb cylinder can vary widely ranging from as few as two full treatments per 20 lb cylinder to over 20 treatments. Local temperature conditions and the filling policies of local gas suppliers may have a significant impact on

the number of treatments per cylinder. Smaller cylinders may only provide sufficient gas for a few procedures and should only be used for emergencies.

A3.1 Specifying connector requirements

A major potential problem in using cryosurgical equipment in low-resource settings is ensuring that the fitting on the equipment matches the fitting on the gas cylinder. Different standards apply to gas cylinder connectors in different countries. To prevent accidental use of the wrong gas, cylinder fittings are deliberately designed differently for different gases. Additionally, the type of fitting can change depending upon the grade of gas and the size of the cylinder. All of these factors complicate the purchase and use of cryosurgery in low-resource settings where the availability of gas cylinder fittings may be different to that in the country where the equipment is manufactured. Guidance on the choice of the correct fitting is provided in the document on gas supplies for cryosurgical equipment (See Annex 5).

A3.2 Gas safety

Both carbon dioxide and nitrous oxide can be hazardous if leaks occur or the exhaust from the cryosurgical unit is not vented properly. Additionally, the gas cylinders are under high pressure and can be hazardous in their own right. Appropriate precautions for working with the gases and handling the cylinders are given in Chapters 2 and 3.

A4. Operational procedures

Cryosurgical treatment is a medical procedure that should only be performed by trained clinical providers. Appropriate clinical training should be provided in advance of using the equipment.

Clinical guidelines on the use of cryosurgical equipment are available in the WHO guidelines on cryotherapy (Annex 3).

¹⁴ BOC Healthcare, Priestley Road, Worsley, Manchester M28 2UT, UK.

General guidelines on the operation of cryosurgical equipment in the treatment of precancerous cervical lesions are given in the Jhpieigo Cervical Cancer Prevention Guidelines for Low-Resource Settings¹⁵. The guidelines are based on the Wallach LL100 cryotherapy system but nevertheless can be generalized to most equipment types. The general steps required to set up, test, use, clean, and troubleshoot the equipment are described. When using equipment from other manufacturers, however, reference must be made to the manufacturer's own instructions for specific guidelines on setting up, testing, using, cleaning, disinfecting and troubleshooting the equipment.

The guidelines recommend that when using carbon dioxide, the risk of the unit becoming blocked by ice particles can be reduced by using the freeze-clear-freeze technique. Basically this consists of beginning the freeze cycle for 15 seconds and then very briefly pressing the defrost trigger for a second or less before reapplying freezing. This cycle is repeated through the whole of the freezing procedure. This procedure is also known as the cough technique.

Seamans et al¹⁶ demonstrated, however, that when using the cough technique with the Wallach LL100 cryotherapy system (with a T-2500 2.5 cm diameter flat probe) the minimum tissue temperatures achieved using either nitrous oxide or carbon dioxide were greater than the -20 °C required for the desired therapeutic effect. When the equipment was used in continuous mode, tissue temperatures below -20 °C were achieved (-40 °C with nitrous oxide and -30 °C with carbon dioxide).

Winkler et al¹⁷ reported very similar results, again using the Wallach LL100 cryotherapy system. The temperature of the cryotip did not drop below -33 °C. The authors cautioned that practitioners performing cryosurgery using the cough technique should be aware that the temperatures obtained may not be sufficient to destroy precancerous tissue. **Since these studies were undertaken, the Wallach LL100 has been recalled and modified for use with carbon dioxide to prevent clogging. Not only is the cough technique now unnecessary, but it is no longer recommended for the cryosurgical treatment of precancerous cervical lesions because of the failure to achieve therapeutically effective temperatures when the technique is used.** Users of older, unmodified Wallach LL100 equipment should contact the supplier for details of the recall.

In an attempt to overcome blockages due to icing, Seamans et al.¹⁸ reported on the use of a gas conditioner to filter and dry the gas before it enters the cryogun. The conditioner was placed in the in the gas supply line between the cylinder and the Cryogun. It contained a commercial calcium sulphate laboratory desiccant, Drierite (W. A. Hammond Drierite Co. Ltd, Xenia, Ohio). The authors concluded that the gas conditioner showed promise in reducing the incidence of blocking, but it has not yet been made commercially available. Follow up work by Winkler et al.¹⁹, however, showed that the device only helped with the Wallach LL100,

¹⁵ Blumenthal PD, McIntosh N. Cervical Cancer Prevention Guidelines for Low-Resource Settings. Baltimore, Jhpieigo, 2005. (http://www.jhpieigo.org/files/CECAP_Manual.pdf)

¹⁶ Seamans Y et al. Effect of cough technique and cryogen gas on temperatures achieved during simulated cryotherapy. *BMC Women's Health*, 2007, 7:16.

¹⁷ Winkler J L et al. Effect of the "cough technique" on cryotherapy freezing temperature. *International Journal of Gynecology and Obstetrics*, 2010, 108: 115–118.

¹⁸ Seamans Y. Preliminary report of a gas conditioner to improve operational reliability of cryotherapy in developing countries. *BMC Women's Health*, 2006, 6:2.

¹⁹ Winkler JL, Jeronimo J, Singleton J, Janmohamed A, Santos C. Performance of cryotherapy devices using nitrous oxide and carbon dioxide. *International Journal of Gynecology and Obstetrics*, 2010, 111: 73–77.

which as stated in the previous paragraph has since been recalled and modified. Using the conditioner with other makes of cryosurgical equipment led to increased tip temperatures. The use of a gas conditioner is therefore not recommended.

A5. Cleaning and disinfection

The cryosurgical unit, cryoshaft and cryotip will all require cleaning and disinfection between patients. Disinfection can present a major problem in low-resource countries. WHO recommends that a solution of sodium hypochlorite with 0.5% available chlorine is used as the disinfectant solution if made using non-potable water. If potable water is available or the water is boiled first, the concentration of available chlorine can be reduced to 0.1%. Other chlorine-releasing chemicals can be used in place of sodium hypochlorite. Options include calcium hypochlorite, sodium dichloroisocyanurate (NaDCC) and chloramine. In all cases the degree of dissolution should be such as to give an available chlorine content of 0.1% if using potable or boiled water and 0.5% if using non-potable water.

When cleaning equipment without a detachable cryoshaft, special care has to be taken to prevent damage to the hand unit. Such units cannot, for example, be immersed in disinfectant.

Alternative chemical disinfection options are severely limited. Treatment with 2% to 4% glutaraldehyde (e.g. Cidex) will provide adequate disinfection but this chemical is expensive, difficult to handle, and may not be available in a low-resource setting.

Other options for disinfecting the cryotips include boiling or steaming to 20 minutes, autoclaving at 121 °C and 106 kPa pressure (15 psi) for 20 minutes (30 minutes if wrapped) or dry heating at 170 °C for one hour or at 160 °C for two hours.

Whatever methods of cleaning and disinfection are used, it is essential that the manufacturers' instructions are followed, otherwise the cryotips could be damaged. Not all manufacturers make cryotips that can be heated or autoclaved and some might be damaged by the chemicals that are used. Read the manufacturers' instructions before use.

Annex 3. WHO guidelines on cryotherapy

PS 12: Cryotherapy

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PRACTICE SHEET 12: CRYOTHERAPY

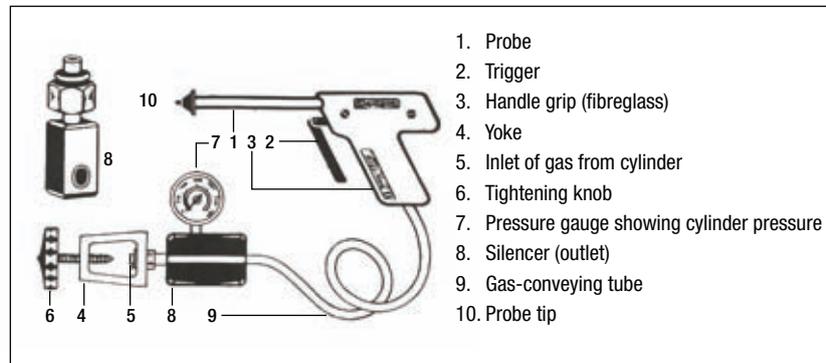
Cryotherapy is the freezing of the abnormal areas of the cervix by the application of a very cold disc to them. It takes only a few minutes and usually only causes some cramping.

The following materials and equipment are needed for cryotherapy:

- speculum, high-level disinfected (it need not be sterile);
- disposable or high-level disinfected examination gloves (need not be sterile);
- cotton swabs for wiping the cervix;
- normal saline solution;
- colposcope, if used in the particular venue;
- cryosurgery unit with adequate gas supply (Figure PS12.1).

For basic equipment to perform a pelvic examination refer to PS7.

Figure PS12.1 Cryotherapy equipment components



Source: Sellors JW, Sankaranarayanan R. *Colposcopy and treatment of cervical intraepithelial neoplasia: a beginners' manual*. Lyon, IARCPress, 2002.

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PS 12: Cryotherapy

PERFORMING CRYOTHERAPY**Before the procedure**

1. Explain the procedure, and why it is important to return for further management as requested. Ensure that the woman has understood and obtain informed consent.
2. Show her the cryotherapy equipment and explain how you will use it to freeze the abnormal areas on the cervix.
3. Prepare the patient for a gynaecological examination, and perform a speculum examination (see Practice Sheet 7).
4. If there is no evidence of infection, proceed with cryotherapy.
5. If there is a cervical infection, provide treatment as described in Annex 8. You may proceed with the cryotherapy, or you may give the patient an appointment to return once the infection is cured.



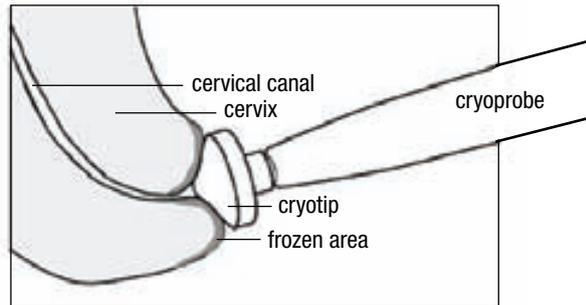
PS6 Informed consent
PS7 Pelvic exam

Procedure

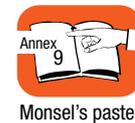
6. Wipe the cervix with a saline-soaked cotton swab and wait a few minutes.
7. Apply acetic acid to outline the abnormality and wait a further few minutes.
8. Tell the woman she might feel some discomfort or cramping while you are freezing the cervix.¹⁶
9. Wipe the cryoprobe surface with saline to ensure optimum effectiveness.
10. Apply the cryoprobe tip in the centre of the os and make sure the probe adequately covers the lesion (Figure PS12.2). If the lesion extends more than 2 mm beyond the probe, discontinue the procedure. Explain to the woman why you are doing this and what needs to be done for her as an alternative.
11. Ensure that the vaginal wall is not in contact with the cryoprobe or you may cause a freezing injury to the vagina.
12. Set the timer and release the gas trigger to cool the probe.
13. You will observe the ice forming on the tip of the cryoprobe and on the cervix (Figure PS12.2). When the frozen area extends 4–5 mm beyond the edge of the cryoprobe, freezing is adequate.

¹⁶ In some cases, the patient may have a vasovagal reaction, with fainting and plummeting blood pressure. If this happens, stop the treatment immediately and raise the patient's legs as much as possible.

Figure PS12.2 Position of cryoprobe on the cervix and ice forming



14. Allow two cycles of freezing and thawing: 3 minutes freezing, followed by 5 minutes thawing, followed by a further 3 minutes freezing.
15. Once the second freezing is complete, allow time for thawing before attempting to remove the probe from the cervix. Removing it before it is fully thawed will pull tissue off the cervix.
16. Gently rotate the probe on the cervix to remove it. The area you have frozen will appear white.
17. Examine the cervix for bleeding. If bleeding is noted, apply Monsel's paste.
18. Do not pack the vagina.
19. Remove the speculum.



Monsel's paste

After the procedure

20. Provide a sanitary pad.
21. Instruct the woman to abstain from intercourse and not to use vaginal tampons for 4 weeks, until the discharge stops completely. This to avoid infection.
22. Provide condoms for use if she cannot abstain from intercourse as instructed. Teach her how to use them.
23. Invite her to return in 2–6 weeks to be checked for healing, and again in 6 months for a repeat Pap smear and possible colposcopy.



Condom use

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PS 12: Cryotherapy

24. Inform her of possible complications and ask her to return immediately if she notes:
- fever with temperature higher than 38 °C or shaking chills;
 - severe lower abdominal pain;
 - foul-smelling or pus-like discharge;
 - bleeding for more than two days or bleeding with clots.
25. Clean and disinfect the cryoprobe and decontaminate the cryogun, tubing, pressure gauge and gas tank:¹⁷
- Decontaminate the cryotherapy unit, hose and regulator by wiping them with alcohol.
 - Wash the cryotip and the plastic sleeve with soap and water until visibly clean.
 - Rinse the cryotip and plastic sleeve thoroughly with clean water.
 - High-level disinfect (HLD) the cryotip and plastic sleeve by one of the following methods:
 - boil in water for 20 minutes; or
 - steam for 20 minutes; or
 - soak in chemical disinfectant (0.1% chlorine solution or 2–4% glutaral) for 20 minutes and then rinse with boiled water.
 - It is critical that the hollow part of the cryotip is completely dry when next used, otherwise the water will freeze and the probe could crack or the treatment not work.
 - Either use a rubber cap to seal off the hollow part of the cryoprobe during processing, or thoroughly dry the cryoprobe before it is reused.
 - If none of the high-level disinfection options are available, the cryotip and sleeve may be disinfected by soaking in 70–90% ethanol or isopropanol for 20 minutes. Allow to air-dry and then reassemble.

Follow-up

26. Perform a pelvic examination to check for healing 2–6 weeks after the cryotherapy.
27. At 6 and 12 months, do a Pap test and a colposcopy and take a biopsy if necessary. Follow up as described in Annex 5.



Flowchart precancer

¹⁷ Some cryoguns get blocked by ice. This can be avoided by pushing the defrost button every 20 seconds to clean the tube. Alternatively, use the cryotherapy gas conditioner developed by PATH.

Annex 4. WHO universal precautions for infection prevention

Annex 1: Universal precautions for infection prevention

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ANNEX 1: UNIVERSAL PRECAUTIONS FOR INFECTION PREVENTION²⁴

Universal precautions are simple measures that help prevent the spread of infection. All health care providers must use universal precautions to protect patients, themselves and other health care workers from the spread of infectious diseases.

The current epidemic spread of bloodborne viruses, including hepatitis B, C and D, and HIV, underscores the importance of paying scrupulous attention to preventing infection in clinical practice. Many transmissible infections are asymptomatic, and it is not always possible to know who is infected. Therefore, precautions against spreading infection should be used with all patients, whether they appear sick or well, and whether their HIV or other infection status is known or not.

Quality control and supervision are essential to ensure that infections are prevented. A pelvic infection after a clinical procedure is an indicator of poor infection-prevention measures.

Infection prevention: universal precautions

Wear latex gloves whenever:

- you handle items or body surfaces that might be contaminated;
- you perform clinical examinations or procedures (cryotherapy, biopsy, endocervical curettage and LEEP), or give injections;
- you clean the area where the patient has been;
- you handle used instruments.

Remember:

- If gloves get damaged, remove them, wash your hands thoroughly, and then put on new gloves.
- Gloves are not a substitute for handwashing.

Wash your hands with soap and water for at least 30 seconds:

- before and after contact with each client or patient;
- if you touch blood or body fluids;
- immediately after you take off latex gloves.

²⁴ Adapted from: *Universal precautions against infectious diseases*. University of Michigan Health System (www.med.umich.edu/1libr/wha/wha_unipre_crs.htm); and Burns AA et al., *Where women have no doctor*. Berkeley, CA, Hesperian Foundation, 1997.

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Annex 1: Universal precautions for infection prevention

Handle contaminated disposable items and clinic surfaces as follows:

- Discard disposable items that are soiled with blood or body fluids in a tightly sealed plastic bag.
- Disposable needles need special handling; use your health facility's protocols.
- Wash linen and reusable cloth items. Use detergent, dry them in the sun, and iron them if possible.
- Clean and disinfect surfaces such as examination tables and floors.

Process reusable instruments and gloves after each use, as follows:

- All instruments that have been in contact with the vagina or cervix (e.g. specula, biopsy forceps, gloves, etc.) should be decontaminated, cleaned, and sterilized or high-level disinfected.
- Cryoprobes should be decontaminated, cleaned, and high-level disinfected.
- The examination or procedure table must be decontaminated after each patient. Other instruments (e.g. colposcope, cryogun, torch lights) must be decontaminated at least once a day, and more often if visibly soiled.

Processing instruments²⁵

There are three basic steps for processing instruments used in clinical and surgical procedures, before they can be reused: (1) decontamination, (2) cleaning, and (3) sterilization or high-level disinfection (HLD).

Decontamination

Decontamination is the process by which used instruments and gloves are made safe for handling; this step inactivates hepatitis B and HIV. To decontaminate instruments and gloves immediately after use, immerse them in a large plastic bucket containing 0.5% chlorine solution for 10 minutes (not longer, as the instruments may become corroded); remove and rinse with clean water. The chlorine solution can be prepared by diluting 1 part household bleach in 9 parts clean water. It must be prepared fresh daily and discarded as soon as it appears dirty. For surfaces in the clinic, 60–90% ethanol or isopropanol can be used as an alternative to chlorine solution.

Cleaning

Soon after decontamination, instruments should be cleaned by a person wearing heavy gloves and glasses or goggles. Use a brush to scrub instruments with water and detergent, and rinse thoroughly with boiled water. Special attention must be given to instruments with teeth, joints and screws.

²⁵ Adapted from: Sellors JW, Sankaranarayanan R, *Colposcopy and treatment of cervical intraepithelial neoplasia: a beginners' manual*. Lyon, IARCPress, 2003.

Sterilization

Sterilization destroys all microorganisms and must be used for all instruments that come into contact with sterile parts of the body, e.g. that penetrate the skin or enter the womb.

Sterilization can be achieved by one of the following:

- Expose instruments to superheated steam in an autoclave: 20 minutes for unwrapped instruments and 30 minutes for wrapped instruments. Autoclaving is the preferred method of sterilization.
- Soak instruments in either 2–4% glutaral for 8 to 10 hours, or 8% formaldehyde for 24 hours. Then rinse thoroughly with sterile water.

High-level disinfection

HLD destroys all organisms except bacterial spores, and is used when sterilization equipment is not available or the instrument is too delicate to be sterilized. One of the following processes can be used for HLD:

- Boil instruments for at least 20 minutes in plain tapwater, which is changed at least daily. Make sure that instruments are fully covered by the water, and start timing after the water with the instruments is fully boiling. Do not add anything to the pot once you have started to time.
- Soak instruments in 0.1% chlorine or 2% glutaral solution for 20 minutes, or 6% hydrogen peroxide for 30 minutes. Rinse thoroughly in boiled water, air-dry and store in a sterile cloth. These chemicals may be corrosive and can reduce the useful life of instruments that are repeatedly disinfected with them.

Supplies and equipment

The following supplies and equipment are needed for infection prevention (depending on the processing methods used):

- clean and boiled water;
- detergent;
- household bleach or commercial chlorine powder;
- one or more sterilizing chemicals (2–4% glutaral, 8% formaldehyde);
- one or more HLD chemicals (0.1% chlorine, 2% glutaral, 6% hydrogen peroxide);
- 60–90% ethanol or isopropanol;
- sterile cloths;
- plastic bucket;

(continued next page)

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Annex 1: Universal precautions for infection prevention

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Annex 1: Universal precautions for infection prevention

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Annex 1: Universal precautions for infection prevention

- scrubbing brush;
- large jars for storage of solutions;
- heavy gloves for cleaning;
- sterile or high-level disinfected gloves and long-handled forceps for handling processed instruments;
- autoclave or vessels for boiling and soaking instruments;
- closet with tight closure to prevent entrance of dust, for storage of processed instruments and supplies.

Annex 5. Details of gas fittings and suppliers by country

Country	Gas Fitting Standard	Bottle Size (empty)	Gas Supplier	Contact Information
Algeria	French		Air Liquid	+234 1 452 3937 or +234 774 6445
Angola				
Benin	French			
Botswana	British			
Burkina Faso	French	20kg	Air Liquide M Foro Didace	+226 70 00 16 99 or +226 71 76 61 70
Burundi	British			
Cameroon	French		fme - Gaz Douala	+237 33 39 23 06
Cape Verde				
Chad	French			
Congo, Republic of	French			
Congo				
Cote d'Ivoire	French		Air Liquide Sivoa	Hien Toho Hien.TOHO@ AirLiquide.com +225 47 18 01 81
Djibouti	French			
Egypt	French			
Equatorial Guinea				
Eritrea				
Ethiopia				
Gabon	French			
The Gambia	British			
Ghana	British		Air Liquide	+322 024052
Guinea	French			
Guinea-Bissau				
Kenya	British		Afrox Kenya with local distributor	
Lesotho	British			
Liberia				
Libya				
Madagascar	French		Air Liquide (SOAM)	+261 23 225 06
Malawi	British			
Mali	French			
Mauritania	French			

Country	Gas Fitting Standard	Bottle Size (empty)	Gas Supplier	Contact Information
Mauritius	French			
Morocco	French			
Mozambique	British	20kg	AMOGAS	+258 2147 51 95 or +258 2147 51 96 mogas@mogas.co.mz
Namibia	British			
Niger	French			
Nigeria	British			
Rwanda	British			
Senegal	French			
Sierra Leone				
Somalia	British			
South Africa	British	6.3kg, 13kg	Afrox in KZN province Air Liquide in NW province	
Sudan	British			
Tanzania	British		Tanzania Oxygen	
Togo	French			
Tunisia	French			
Uganda	British		Uganda Oxygen Ltd	+41 257717 or + 41 257727
Zambia	British	31.1 kg	Afrox SA with local distributor	
Zimbabwe	British			
India	British			
Mexico	US			
Bolivia	US			
Chile	US			
Paraguay	US			
Guatemala	US			
El Salvador	US			
Honduras	US			
Nicaragua	US			
Costa Rica	US			
Panama	US			
Dominican Republic	US			

Country	Gas Fitting Standard	Bottle Size (empty)	Gas Supplier	Contact Information
Ecuador	US			
Puerto Rico	US			

Additional information on gas suppliers

The following companies supply gases, including medical-grade carbon dioxide, and have local distribution centres around the world:

Linde AG: <http://www.linde-gas.de/international/web/lg/de/like35lgde.nsf/docbyalias/homepage>

Messer: <http://www.messergroup.com/de/index.html>

Tyczka: <http://www.tig.de/>

Praxair: <http://www.praxair.com>

For more information, please contact:

Department of Reproductive Health and Research
World Health Organization
Avenue Appia 20, CH-1211 Geneva 27, Switzerland
Fax: +41 22 791 4171
E-mail: reproductivehealth@who.int
www.who.int/reproductivehealth



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