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Considerations When Selecting Conical Tubes for Centrifugation Applications

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Key Words
Conical centrifuge tubes, centrifuge rotors and adaptors, RCF, RPM

Background

Laboratory centrifuges are common, everyday instruments. While centrifuge usage is widespread, the selection of the proper centrifuge and rotor system, along with the proper centrifuge tube consumable, can often be a challenging experience. There are several factors to consider when selecting the correct conical tube for centrifugation. These include the relative centrifugal force required, the fit of the particular tube in the rotor, sample volume, and the compatibility of the sample to the tube material. Understanding the requirements of a centrifugation application before selecting a conical tube can prevent sample leakage or loss, allow for easy sample recovery, and reduce the risk for potential damage to the centrifuge and rotor.

Factors to consider when choosing a conical centrifuge tube

A. RPM vs. RCF

All centrifuge tubes have a maximum speed rating determined by the manufacturer. Vessels used at speeds higher than the recommended rating can fail, resulting in sample loss and potential damage to the centrifuge and rotor. Most protocols specify speed in either revolutions per minute (RPM) or relative centrifugal force (RCF). It is crucial to understand the difference between RPM and RCF. The rotor revolves at the specified RPM and the force applied to the contents is dependent on the rotor's radius, with larger radii applying greater force on the sample. RCF represents the gravitational force being applied to the sample. It determines the centrifugation outcome independent of rotor size. RCF is measured in force x gravity, or g-force, and is more relevant to the actual impact and outcome of the centrifugation than RPM. Users should verify the required RCF by their specific applications to ensure that the required centrifugation force does not exceed the manufacturer's specified g-force rating.

B. Fit of the conical tube in the centrifuge rotor

It is important to note that the centrifuge tube performance largely depends on how well the tube fits in the rotor (or rotor adapter). For optimal tube performance it is imperative that there is contact between the tube and the rotor/adapter so that centrifugal force can be distributed to the rotor rather than the tube. Forces exerted directly on the conical tube may cause stress lines, bulging, or cracking. For example, when using a swing-out bucket rotor in a centrifuge unit, the direction of the g force centers on the conical bottom of the tube locking the tube in the center position of the rotor. In some cases, this does not allow the lower portion of the tube to make contact with the rotor/adapter. The centrifugal forces on the side wall of the conical tube cannot be transferred to the rotor and may cause damage to the lower portion of the tube (Figure 1).

When using a fixed angle rotor in a centrifuge unit, the side of the tube makes contact with the rotor/adapter and most of the centrifugal force exerted on the tube can be transferred to the rotor (Figure 2). Consequently, the conical tube in a fixed angle rotor can be spun at much higher RCF in comparison to a swing-out bucket rotor.

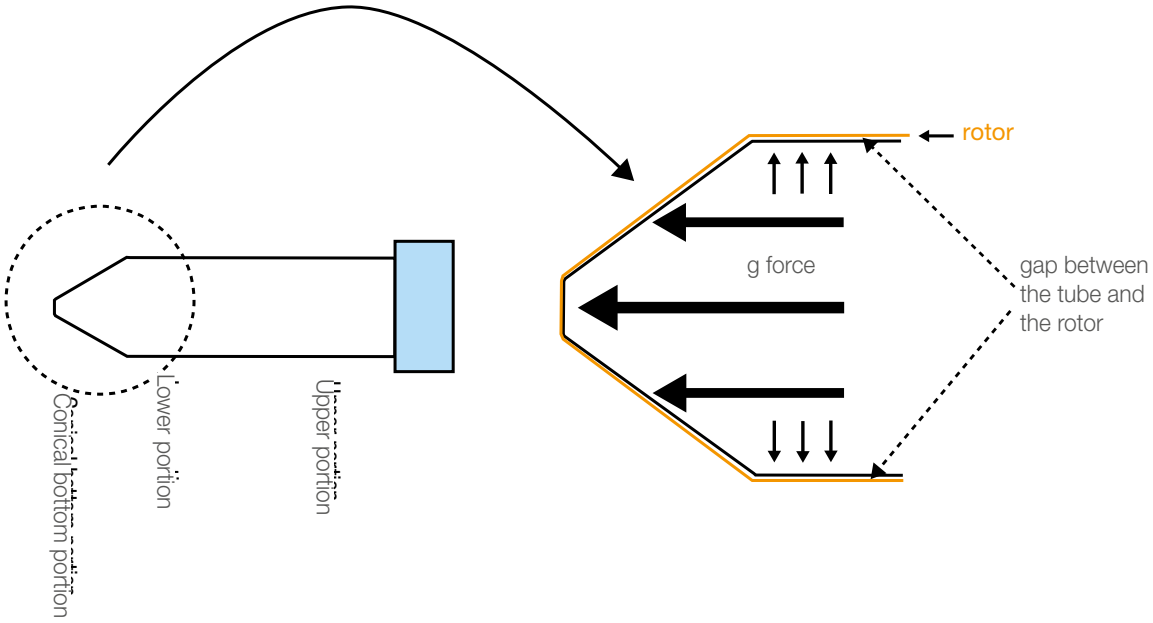

Figure 1. Swing-out bucket rotor and tube fit illustration. Centrifugal forces are exerted on the conical and lower portion of the tube. The imperfect fit of the lower portion of the tube to the rotor leaves a gap which may cause tube damage.

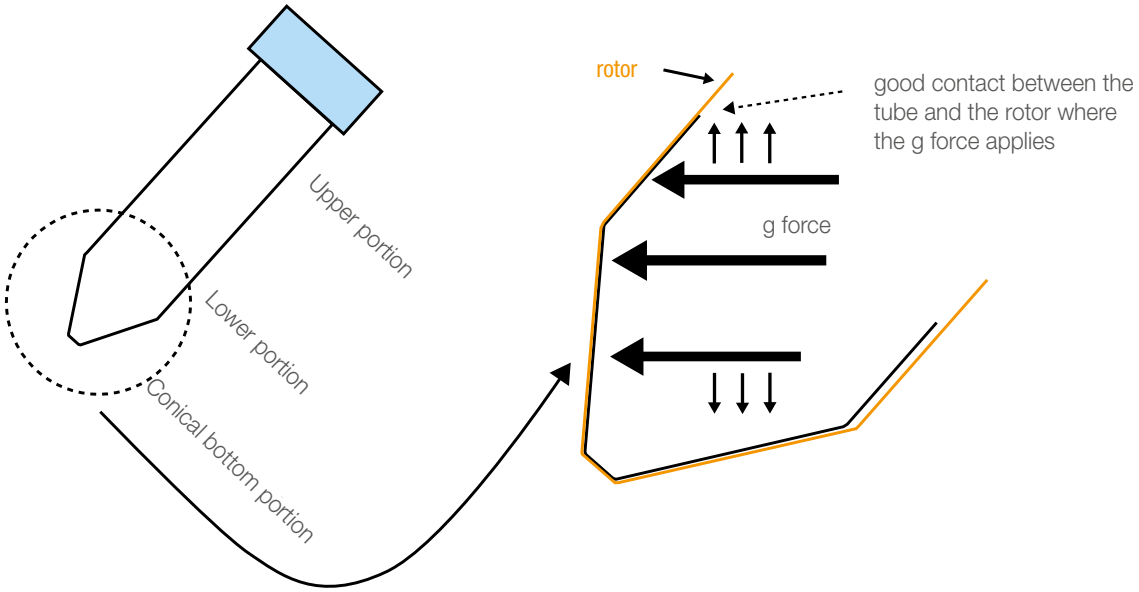

Figure 2. Fixed angle rotor and tube fit illustration. Centrifugal forces are exerted on the sides of the tube and transferred to the rotor/adapter.

Table 1 and Table 2 display the recommended maximum RCF for the Thermo Scientific™ Nunc™ 15mL and 50mL conical tubes based on tests of 9 models of rotors in three types of centrifuge units. In most cases, a rotor adapter is needed to ensure good fitting of the tube to the rotor.

Table 1. Recommended Maximum RCF for Thermo Scientific™ Nunc™ 15mL Conical Tubes (Catalog # 11397201, 11307211)

Thermo Scientific Centrifuge Model	Thermo Scientific Rotor Model	Thermo Scientific Adapter Catalog #	Maximum RCF (x g)
Legend™ 1XR	BIOShield™ 720	10597004	3500
Legend 1XR	Fiberlite F15-6x100y	10658612	24652*
Legend 1XR	TX-400	10308054	4696*
Legend 1XR	TX-200	10194494	5580*
Multifuge™ X3R	TX-750	10287707	4816*
Multifuge X3R	BIOShield 1000A	11874501	5000
Multifuge X3R	Fiberlite F15-8x50y	010-0378-06	24446*
Multifuge X3R	BIOLiner	11894491	2739*
Evolution™	Fiberlite F13-14x50cy	010-0378-06	15000
LYNX 6000	Fiberlite A21-24x15c	not necessary	18500
LYNX 6000	BIOFlex HC	13419409	6500
LYNX 6000	BIOFlex HS	15342137	7000

* Maximum speed for the centrifuge/rotor system is reached.

Table 2. Recommended Maximum RCF for Thermo Scientific Nunc 50mL Conical Tubes (Catalog # 11347201, 11317211)

Thermo Scientific Centrifuge Model	Thermo Scientific Rotor Model	Thermo Scientific Adapter Catalog #	Maximum RCF (x g)
Legend 1XR	BIOShield 720	10247154	6500
Legend 1XR	Fiberlite F15-6x100y	10318612	23500
Legend 1XR	TX-400	10586394	4696*
Legend 1XR	TX-200	10082534	5580*
Multifuge X3R	TX-750	10491445	4816*
Multifuge X3R	TX-750	11791268	4816*
Multifuge X3R	BIOShield 1000A	11864501	6500
Multifuge X3R	Fiberlite F15-8x50y	not necessary	20000
Multifuge X3R	BIOLiner	11884491	2739*
Evolution™	Fiberlite F13-14x50cy	not necessary	15000
LYNX 6000	Fiberlite A21-24x15c	not necessary	13000
LYNX 6000	BIOFlex HC	11884491	7068*
LYNX 6000	BIOFlex HS	15312137	10025*

* Maximum speed for the centrifuge/rotor system is reached.

C. Chemical compatibility

In addition to the maximum RCF, when evaluating centrifuge tubes it is important to make sure that the sample components will not harm the plastic tube material. Chemicals can affect the strength, flexibility, surface texture, color, and shape of the plastic. Chemical resistance is influenced by temperature, duration and frequency of exposure, chemical concentration, and centrifugal force. Physical and chemical changes which may be caused by chemical exposure include:

- Absorption of solvents, resulting in softening or swelling of the plastic
- Stress-cracking of the plastic
- Permeation of solvent in the sample through the plastic
- Dissolution of polymer in the sample

The Nunc conical centrifuge tubes are made of premier quality polypropylene. Table 3 displays information on chemical compatibility of common reagents to polypropylene centrifuge tubes.

D. Sample volume

Before selecting a centrifuge tube size, the desired sample volume should be determined. The sample volume is limited to the available rotors in the laboratory and the protocol being used. Generally, a centrifuge tube should be filled at least 75%. In some cases, such as with ultracentrifuge tubes, it is required that tubes are completely filled to prevent failure. Using centrifuge tubes less than half filled to capacity can lead to high levels of material stress and can result in tube failure. If the available sample volume is smaller than the available rotor capacity, adapters are available for most rotors from the manufacturer (Table 1, Table 2). Adapters allow a smaller-volume tube to be used at the appropriate fill volume. This is essential when the recommended maximum RCF is going to be applied for centrifugation.

Table 3. Chemical Compatibility of Common Reagents to Polypropylene Centrifuge Tubes

Classification	Chemical	Rating
Alcohols	Butanol, pure	S
	Ethanol, 100%	S
	Isopropanol, 100%	S
	Methanol, 15%	S
	Methanol, 98% x-750	S1
Cryopreservation Agents	Dimethyl sulfoxide (DMSO), pure	S
	Glycerol	S
Detergents	Sodium Dodecyl Sulfate (SDS), pure	S
	Triton X-100, pure	S
	Tween-20	S
Fixatives	Acetone, 50%	S
	Acetone, pure	M
	Formaldehyde, 10%	S1
	Formaldehyde, 30%	M
	Formalin, 10%	S1
	Formalin, 30%	M
	Gluteraldehyde, pure	S
	Paraformaldehyde, pure	M
Other	Beta- Mercaptoethanol, pure	S
	Cell culture media and sera	S
	EDTA, pure	S
	RNAzol	S
	Trypsin	S
	Toluene, pure	U
	Xylene, pure	U

Key:

S = Satisfactory

S1 = Satisfactory, may cause discoloration.

M = Marginal; may be satisfactory for use in a centrifuge, depending on length of exposure and speed. Testing under operating conditions is suggested before actual run.

U = Unsatisfactory; not recommended.

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Summary

As in most endeavors, gathering the correct information ahead of time is essential. In this study, we demonstrated the important factors to consider when selecting the conical tubes for centrifugation so that sample leakage or loss is prevented. Choosing the correct centrifuge consumables also ensures proper execution of centrifugation, and reduces the risk for potential damage to the centrifuge and rotor. The factors we discussed in this article include the RCF required by the protocol, the fit of the particular conical tube in the rotor, sample volume, and the chemical compatibility of the sample to the tube material. Users should verify the maximum RCF of the centrifuge tube to ensure that the required speed does not exceed the manufacturer's rating. Here, we recommended the maximum RCF of the Nunc 15mL and 50mL conical tubes in several Thermo Scientific centrifuge and rotor systems while taking these factors into consideration.

References

Goodman, Tammy (Thermo Scientific). Selecting Centrifuge Consumables. American Laboratory April 2009.

Thermo Scientific, NALGENE Centrifuge Tubes and Bottles Your Complete Guide to Centrifuge Ware, 2001

Ordering Information

Cat. No.	Volume, mL	Packaging	Material	Units per pack/case
11397201	15	Bulk	PP	50/500
11307211	15	Racked	PP	25/500
11347201	50	Bulk	PP	25/500
11317211	50	Racked	PP	25/300

All centrifuge tubes are Sterile – SAL 10^{-6}, Leak proof, USP Class VI, Non-pyrogenic, Non-cytotoxic and RNase/DNase Free.