TNL Series Attenuated Total Reflectance (ATR) Tunnel Cells

Hellma® Analytics
Axiom Technology

Precise mid–IR chemical analysis of stationary or flowing liquids for on–line or in the laboratory.

Axiom Tunnel Cells[1] provide both the high degree of analytical accuracy and the rugged reliability required for diverse demanding analyses. As a result, these devices can create new opportunities for FTIR Spectroscopy in application areas ranging from supercritical fluid analysis and HPLC detection, to process methods development and even the instrumentation of large process reactions.

Tunnel Cell models are available in standard flow cell and temperature controlled configurations. They install quickly in any spectrometer sample compartment and can also be easily "plumbed" with Axiot™ optical transfer modules for outboard use. Standard models feature sample volumes ranging from 40 microliters to 20 milliliters and can be operated at pressures to 20 bar. (Optional higher pressure versions are also available.) The helical flow geometry eliminates dead volume and maximizes cleaning efficiency. Even highly viscous samples can be analyzed and then rapidly flushed out with no measurable sample retention.

Tunnel Cells were designed to meet the uncompromising requirements of continuous duty on–line analysis. Stainless steel construction, integral permanently aligned optics, and integral temperature control insure the high level of reliability needed for process applications

These features also provide valuable benefits for the laboratory analyst. You can perform true quantitative IR liquid analysis with no need for cell calibration and with absolute confidence in your results.

THE TUNNEL OPTICAL DESIGN

The Axiom Tunnel optical design is a distinct departure from earlier ATR flow cell designs. Performance limitations encountered with previous cells resulted largely from their use of strongly focused IR radiation at the input end of the internal reflectance element. Since both penetration depth and number of reflections are dependent on angle, this approach leads to absorbance nonlinearity and a marked variation of calibration with optical adjustment.

The Tunnel optical design circumvents these problems by using non focusing conical optics to concentrate the incident radiation within a narrow range of angles in the ATR rod (Figure 1). This basic design, combined with the fact that the conical optics and the ATR element are fixed in place by the mechanical structure, yields unprecedented data linearity and repeatability[2]. As a result, a Tunnel Cell will provide identical performance run after run, making true mid-infrared and UV–Visible quantitative analysis of liquids a reality.

OPTIMIZED LIQUID FLOW GEOMETERY

The use of a circular cross section ATR element provides several advantages over designs employing rectangular elements. Most important is the fact that it allows the use of both highly reliable O–ring seals and an optimized helical flow geometry.

Fluid flowing into the cell spirals around the element several times before exiting – reaching every portion of the cell volume and flowing at much greater velocity than it would following a direct path to the output orifice.

FEATURES:

- Rugged, adjustment–free design
- Absolute repeatability
- Unmatched absorbance linearity
- Rapid sample cleanout
- Compatible with laboratory and process applications
- Fiber-optic coupled UV–Visible versions available (See data sheet: PS-FNL)

REFERENCES:

1. U.S. Patents No. *4,988,195* and *5,954,920*
2. Hellma Axiom Technical Note AN-902

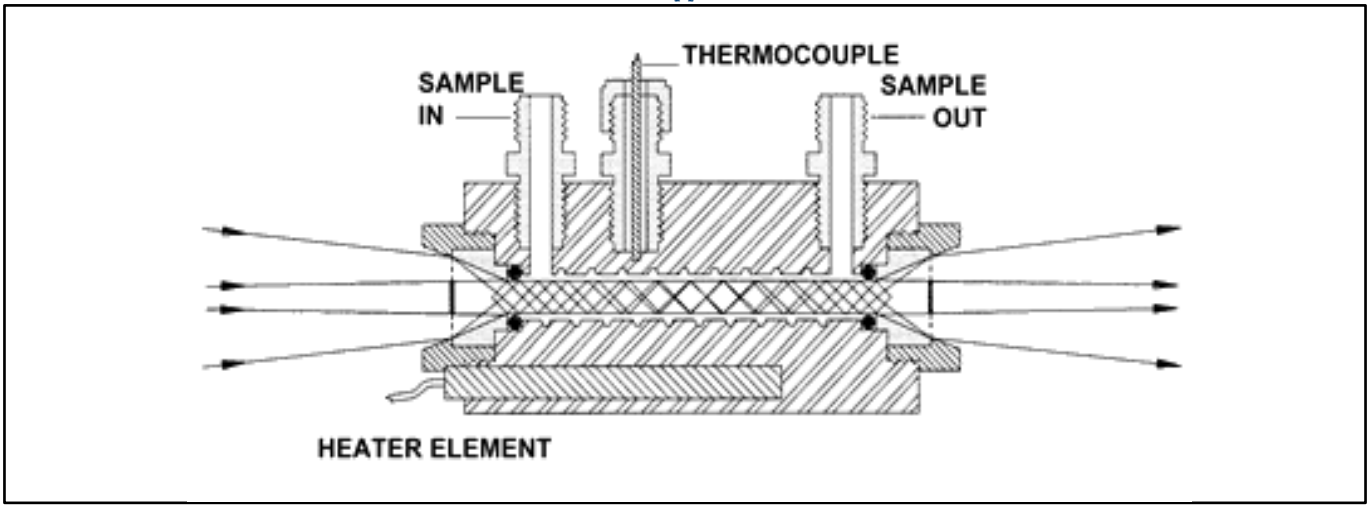

Figure 1: Model TNL–130H with a typical focused sample region optical geometry. The Tunnel optical design maximizes the collecting aperture while minimizing the distribution of rays within the ATR element. For the example shown (f:4 optics), the extreme rays are confined to a range of +1.8 degrees within the element.

STANDARD TUNNEL CELLS FOR MID-INFARED OPERATION

Table 1, provides a list of standard Tunnel Cell models. Tunnel Cell models are specified by a combination of a three digit model number (120, 130) and a pair of suffixes in the following form: XY. The basic model number gives an indication of the element size and approximate sample volume.

Letter suffix "X" indicates structural options such as standard helical flow housing or high temperature. The number suffix "Y" is used to indicate the internal reflectance element material. Table 2 describes the available element materials. If a number is not specified, the element is assumed to be ZnSe.

INTEGRATED TEMPERATURE CONTROL

Tunnel Cell models having the suffix "H" feature temperature control capability integrated into the cell structure. No separate heating or cooling jacket is required. The temperature can be controlled by a cartridge heater and thermocouple (both provided). The operation requires a commercial temperature controller.

HIGH PRESSURE OPERATION

The mechanical designs of all Tunnel Cells are compatible with operation at pressures to at least 80 bar. However, individual internal reflectance elements may not tolerate this full range. If your application requires operation above 20 bar, please inquire with Axiom regarding pretesting to insure that the element delivered with your cell is compatible with you anticipated range of operating pressures. Custom designs are also available for even higher pressures.

INDUSTRIAL SYSTEM CONFIGURATIONS

OUTBOARD OPERATION

All Tunnel Cell models are compatible with the Axiot System of optical transfer modules. This provides considerable freedom for operation outside the spectrometer sample compartment - a vital feature for on-line applications where it's often impractical to pipe the sample to the spectrometer.

In the laboratory, outboard operation leaves the sample compartment free for other tasks and eliminates the possibility of instrument damage due to a chemical spill. For many applications, it is preferable to install a Tunnel Cell inside a fume hood with the spectrometer located outside on the bench top. This capability is easily provided by Axiot transfer optics and a pair of TNA–226 or TNA–326 adaptors (for TNL–120 or TNL–130 Series cells respectively). For ultimate sampling flexibility, Tunnel cells can be integrated into a complete AXM–601 remote sampling module. Contact us directly for more details.

INTEGRATED QUALITY CONTROL CONFIGURATIONS

The use of modular Axiot components allows the configuration of a wide variety of Tunnel optical systems for specialized applications. In addition, the cells can be combined with off–the–shelf temperature control, switching, and pumping equipment to provide integrated systems for quality control functions such as incoming inspection, final test, or near–line process sampling. Axiom is prepared to quote on such dedicated systems to meet any of your QC needs.

ON-LINE PROCESS MONITORING

Rugged, adjustment free construction and a high degree of measurement accuracy make Tunnel cells ideal for on–line process applications. For example, sample volumes in many pilot plant processes are quite small.

Such processes can be monitored by using a Model TNL–120 Micro Tunnel Cell. When the process is subsequently scaled up, the monitoring system can be scaled to match by using Tunnel Cells with larger volume flow diameters and 1/2 or 1" NPT fittings. These have been developed specifically for larger scale process applications involving either viscous fluids or high flow rates.

Axiom also offers a complete family of ATR immersion probes for in–situ monitoring of batch reactions. As a result, the chemistry of a given process can often be modeled by using data obtained with a Tunnel Cell before proceeding to in–situ monitoring using a probe.

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CUSTOM MODIFICATIONS

Among the many customizations we have provided are specialized fittings, fabrication of cells from non–standard materials such as Hastelloy C–276 or Monel, and installations using multiple cells and pneumatic switches for automated parallel analysis. These are only a few of the many sampling solutions that Axiom can provide.

TABLE 1: STANDARD TUNNEL CELL MODELS

	Element Dimensions (diameter x length)	Effective Reflections (Y = 1, 2, or 3)	Optical Aperture (diameter)	Flow Volume	Liquid Fittings
TNL–120XY (Micro)	3.2 mm x 40 mm	10	8 mm	40 µL	⅛" NPT
TNL–130XY (Standard)	6.4 mm x 82 mm	11	16 mm	2 mL	⅛" NPT

Notes:

1. The model designations above include a suffix (XY), where "X" indicates the housing option and "Y" indicates the ATR element material.

   Housing Options

   X = A Standard helical flow geometry – for ambient temperature operation.
   X = H Cartridge heater, insulated stand, and thermocouple (for use with user supplied commercial temperature controller). Maximum temperature: 260 C.

   Element Materials

   Refer to Table 2 for mid-IR element materials. For UV-visible elements, see data sheet PS-FNL.

2. The maximum recommended pressure for all models is 20 bar. Contact Axiom regarding higher pressure options.

3. Interface options are available to match Tunnel Cells to the sample compartments of individual spectrometers. Adaptors are also available to mate Tunnel cells to the Axiot system of transfer optics.

TABLE 2: AVAILABLE MID-INFARED ELEMENT MATERIALS

"Y"	Element Material	Cone Half Angle	Angle of Incidence	Number of Reflections (TNL-130XY)	Spectral Cut-off (cm-1)	Chemical Incompatibilities
1	ZnSe	45°	45°	11	670	Acids, Conc. Bases
2	AMTIR-1	45°	45°	11	880	Bases
3	ZnS	45°	45°	11	980	Strong Oxidizers, Some bases
4	Ge	30°	34°	16	700–8701	H2SO4, Aqua regia
5	Cubic Zirconia	60°	53°	8	2,000	HF, H2SO4
6	Si	30°	34°	16	1,450	HF, HNO3
7	Sapphire	60°	51°	9	2,300	Conc. acids and bases

Note 1. Model dependent

Hellma GmbH & Co. KG. – Klosterrunsstraße 5, 79379 Müllheim, Germany
Tel: +49 7631 182 1020 – Fax: +49 7631 182 1011
www.hellma-axiom.com – E-Mail: sales.analytics@hellma.com