**Intended Use**

*S. aureus* PNA FISH is a qualitative nucleic acid hybridization assay intended for identification of *Staphylococcus aureus* on smears made from positive blood cultures containing Gram-positive cocci in clusters observed on Gram stain.

Sub-culturing of positive blood cultures is necessary to recover organisms for susceptibility testing and/or differentiation of mixed growth.

*S. aureus* PNA FISH is intended as an aid in the diagnosis of *S. aureus* bacteremia.

**Summary and Explanation**

*S. aureus* is well recognized as a leading cause of both community and hospital-acquired bacteremia.

Identification of *S. aureus* species in blood cultures is routinely based on presumptive identification as Gram-positive cocci in clusters followed by final identification after subculture and biochemical analysis (1).

*S. aureus* PNA FISH is a fluorescence in situ hybridization (FISH) method using PNA probes hybridizing to unique *S. aureus*-specific ribosomal RNA sequences (2,3,6-7).

The test provides rapid identification of *S. aureus* on smears made from positive blood cultures leading to improved patient therapy and management (4,5).

**Principle of the Procedure**

A fluorescein-labeled, *S. aureus*-specific PNA probes is added to a smear prepared from a blood culture. Hybridization is performed at 55°C for 30 min. The hybridization is followed by a post-hybridization wash at 55°C for 30 min. with Wash Solution. Finally, the smear is mounted with Mounting Medium and examined by fluorescence microscopy.

**Reagents**

*S. aureus* PNA FISH is comprised of the following kit components:

- **Fixation Solution**: 3 mL phosphate-buffered saline with detergent.
- **S. aureus PNA**: 1.5 mL PNA probes in hybridization solution. Contains 30% formamide.

**Safety Precautions**

Establish precautions against microbiological hazards.

- Do not eat, drink, smoke, apply cosmetics, store or prepare foods within the designated work area.
- Dispose of reagents in accordance with federal, state and local regulations.

**Technical Precautions**

- Reagents must not be used after the expiration dates printed on the labels.
- Reagents are provided at fixed concentrations. Assay performance may be affected if the reagents are modified in any way or are not stored under the recommended conditions as detailed in “Storage of Kit Components”.
- Avoid microbial contamination of reagents.
- Avoid any cross-contamination of samples and reagents, as this may give rise to erroneous results.
- Do not allow dropper bottle tip to touch the smear as this may cause cross contamination of material between slides, or cause contamination of the reagent.
- Do not use filters other than the Dual Band Filter (AC003 or AC007).
Do not use microscope slides other than the Microscope Slides (AC001). It is important that the microscope is functioning properly. Make sure that the microscope bulb is correctly adjusted and has not aged beyond its specified lifetime.

### Storage and Preparation of Kit Components

To ensure optimal kit performance, it is important that kit components are stored and prepared according to the following instructions:

**Storage**

Store kit components at 2-8°C. Place kit components at room temperature prior to use and return the kit components to 2-8°C after use.

**Preparation of Wash Solution**

Prepare working strength Wash Solution by adding 4 mL of 60x Wash Solution followed by 240 mL of fresh deionized or distilled water directly to the Staining Dish. Store remaining concentrate at 2-8°C.

**Preparation of Mounting Medium**

The Mounting Medium should be left at room temperature for at least 5 min. before use.

### Specimen Collection and Preparation

#### Preparation of Smears

- Follow the blood culture system manufacturer’s instruction to properly mix the blood culture bottle before smear preparation. Follow established laboratory procedures on sub-culturing of positive blood culture.
- Place one drop of Fixation Solution on a well on the microscope slide.
- Transfer 10 µL or a small drop from a ventilation needle of a blood culture to the Fixation Solution and mix gently to emulsify.
- Fix the smears by either heating them for 20 min. at 55°C or allow the smears to dry and fix them by methanol-fixation or by flame-fixation.

#### Test Procedure

**Material Provided**

*S. aureus* PNA FISH®

Each kit contains sufficient material for 50 tests. Reagents are supplied ready for use except where indicated. The expiration date of the kit is as indicated on the outer box label.

**Material Required and Available from AdvanDx**

<table>
<thead>
<tr>
<th>Item</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microscope Slides</td>
<td>AC001</td>
</tr>
<tr>
<td>Coverslips</td>
<td>AC002</td>
</tr>
<tr>
<td>Dual Band Filter</td>
<td>AC003 or AC007</td>
</tr>
<tr>
<td>Staining Dish</td>
<td>AC004</td>
</tr>
<tr>
<td>PNA FISH Workstation</td>
<td>AC005</td>
</tr>
<tr>
<td>Water Bath</td>
<td>AC006</td>
</tr>
<tr>
<td><em>S. aureus Control Slide</em></td>
<td>CS001</td>
</tr>
</tbody>
</table>

Positive Control well contains mixture of *S. aureus* ATCC#29213, and Negative Control well contains *S. epidermidis* ATCC#14990.

**Material Required but Not Provided**

- Water, deionized or distilled.
- Fluorescence microscope equipped with a 60x or 100x oil objective.
- Immersion oil. Must comply with the microscope objective and be non-fluorescent.

**Assay Procedure**

All steps are performed at room temperature unless otherwise stated.

Before starting the assay procedure, prepare working strength Wash Solution in the Staining Dish, add cover and start preheating in the water bath (55 ± 1°C). Do not reuse Wash Solution, but prepare fresh working strength Wash Solution for each run.

**Hybridization**

- Add one drop of *S. aureus* PNA to the well on the microscope slide with the smear.
- Add coverslip. Avoid air bubbles. Use a sterile loop to remove resin beads if needed.
- Incubate for 30 ± 5 min. at 55 ± 1°C.

**Stringent Wash**

- Immerse slide in preheated Wash Solution at 55°C and carefully remove the coverslip. Often, the coverslip slides off by gently agitating the slide in the Wash Solution. Occasionally, the coverslip must be pushed off with forceps.
- Incubate for 30 ± 5 min. at 55 ± 1°C.
- Allow the slide to air dry

**Mounting**

- Add one drop of Mounting Medium to the smear.
- Add coverslip. Avoid air bubbles.
- Examine slide as described below within 2 hours.
- Do not expose the slides to direct sun light or other strong light sources as this may lead to fluorescence quenching.

**Quality Control**

Control material should be tested in accordance with guidelines or requirements of local, state, and/or federal regulations or accrediting organizations, including controls grown in liquid media.

Quality control for fluorescent testing should be done each time testing is performed. The QC results should be able to monitor for appropriate testing conditions, particularly those affecting hybridization stringency and cell wall penetration, since PNA methodology is designed to optimize cell wall penetration.

Use *S. aureus* Control Slide (CS001) or prepare smears from liquid cultures of laboratory or reference strains of *S. aureus* as a Positive Controls and *S. epidermidis* as a Negative Control as described above under Specimen Collection and Preparation. The smears may be stored for up to 1 month at room temperature.

*S. aureus* must test positive, and *S. epidermidis* must test negative in accordance with the Interpretation of Results below.

**Procedural Notes**

**Preparation of Smears:**

It is recommended to use the same type of fixation (heat, methanol or flame fixation) that is used for Gram-staining. To reduce the reporting time, smears for PNA FISH may be prepared in parallel with smears for Gram-staining.

*Note: Fixation Solution is designed for optimal performance in the identification of Gram-positive bacteria and Yeast and must not be interchanged with GN Fixation Solution from other PNA FISH tests for Gram-negative bacteria.*

**Temperature Control:**

It is important that the temperature of the PNA FISH Workstation has reached 55°C prior to starting the hybridization and that Water Bath Solution has reached 55°C prior to immersion of the slides. The temperature of the Water Bath should be checked using a thermometer as outside temperature readings may not always be accurate.

**Parallel Testing Using Different PNA FISH Tests:**

The PNA FISH kits are designed for parallel testing. The PNA FISH kits are designed for parallel testing. Parallel testing using different PNA FISH tests is possible, but the reporting time may be increased due to the need for separate wash solutions and stringency conditions.

**Major Blood Culture Systems and Bottle Type Compatibility:**

The PNA FISH platform is compatible with the commercially available continuously monitoring blood culture systems and bottle types, including those which are supplemented with charcoal, resins and/or sodium polyethanesulfonate.
Interpretation of Results
Examine slides using a fluorescence microscope. The smear appears in general reddish. *S. aureus* is identified as multiple bright green fluorescent clusters of cocci in multiple fields of view whereas non-*S. aureus* appears non-fluorescent. Definitive identification is pending subculture and additional microbiological evaluation.

Representative examples of green-positive *S. aureus* (left) and negative (right) test results.

Troubleshooting
False positive Control and Sample test results may occur if the Dual Band Filter (AC003 or AC007) is not used, or by contamination of the specimens.

False negative Control or Sample test results may occur if AdvanDx Microscope Slides (AC001) are not used or if the temperature is not accurately controlled during hybridization and washing.

Please refer to the Precautions and Limitations sections in this product insert or contact AdvanDx.

Limitations
False-positive results with *S. schleiferi* may occur due to a single base mismatch (6).

Other non-*S. aureus* species, including *Stomatococcus* species, may potentially cause false positive results.

In the event of co-infection, the accuracy of the *S. aureus* PNA FISH for detecting *S. aureus* at the LoD (10³ CFU/mL) concentration in the presence of coagulase-negative *Staphylococcus* at the concentration higher than (> ) 10³ CFU/mL has not been established and therefore unknown.

Insufficient pediatric bottles have been tested in clinical studies, therefore, the performance of this assay with pediatric bottles is unknown.

False positive green autofluorescence may occur if a standard FITC filter is used instead of the Dual Band Filter.

False negative results may infrequently occur due to mixed growth or due to error in assay technique.

The type and condition of the instrumentation used will influence the visual appearance of the image obtained. The fluorescence may vary due to the type of microscope employed, the light source and the level of rRNA in the cells. Each laboratory should establish its own criteria for reading the results using appropriate controls.

Isolation on solid media is needed to differentiate mixed growth with other organisms.

The product has not been validated with specimens other than blood cultures.

Expected Results
The expected *S. aureus* positive result rate from GPCC positive blood culture bottles is 30%-43% depending on institutional and patient population (2,4,6-8).

Performance Characteristics
Clinical Studies
The performance of *S. aureus* PNA FISH has been assessed in three clinical laboratory studies. A total of 208 routine GPCC positive blood culture bottles were included in the studies, which showed 100% (208/208) agreement between *S. aureus* PNA FISH and conventional methods; and 98.4% agreement between the shortened and the original *S. aureus* PNA FISH procedure. These studies included three commercially available, continuously monitoring blood culture systems (Bact/ALERT, bioMérieux, NC, BACTEC, Becton Dickinson, MD and VersaTREK, Magellan Biosciences, OH).

Performance Data for *S. aureus* PNA FISH (Shortened) vs. Conventional Methods

<table>
<thead>
<tr>
<th>Study</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Blood Culture System</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100% (15/15)</td>
<td>100% (35/35)</td>
<td>BacT/ALERT</td>
</tr>
<tr>
<td></td>
<td>95% CI (81.9-100)</td>
<td>95% CI (91.8-100)</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>100% (32/32)</td>
<td>100% (71/71)</td>
<td>VersaTREK</td>
</tr>
<tr>
<td></td>
<td>95% CI (84.2-99.9)</td>
<td>95% CI (95.8-100)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>100% (13/13)</td>
<td>100% (42/42)</td>
<td>BACTEC</td>
</tr>
<tr>
<td></td>
<td>95% CI (79.4-100)</td>
<td>95% CI (93.1-100)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100% (60/60)</td>
<td>100% (148/148)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>95% CI (95.1-100)</td>
<td>95% CI (98-100)</td>
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</tr>
</tbody>
</table>

Performance Data for *S. aureus* PNA FISH (Shortened) vs. *S. aureus* PNA FISH (Original)

<table>
<thead>
<tr>
<th>Study</th>
<th>Positive Agreement</th>
<th>Negative Agreement</th>
<th>Blood Culture System</th>
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<tbody>
<tr>
<td>A</td>
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<td>100% (35/35)</td>
<td>BacT/ALERT</td>
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<tr>
<td></td>
<td>95% CI (81.9-100)</td>
<td>95% CI (91.8-100)</td>
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<tr>
<td>B</td>
<td>96.9% (32/33)</td>
<td>100% (70/70)</td>
<td>VersaTREK</td>
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<td></td>
<td>95% CI (84.2-99.9)</td>
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<tr>
<td>Total</td>
<td>98.4% (60/61)</td>
<td>100% (148/148)</td>
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<tr>
<td></td>
<td>95% CI (91.2-100)</td>
<td>95% CI (98.0-100)</td>
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</table>

Analytical Sensitivity
The detection limit for *S. aureus* was determined to be approximately 10⁵ colony-forming units per mL by serial dilutions of positive cultures. This is consistent with the analytical sensitivity of slide-based staining techniques.

Analytical Specificity
*S. aureus* PNA FISH has been collectively tested on 148 laboratory and reference strains comprising 46 *S. aureus* strains and an additional 66 Gram-positive organisms, 32 Gram-negative organisms and 5 yeast strains which included phylogenetically related bacteria species and a variety of clinically significant species. All (46/46) *S. aureus* were green...
positive, 2/2 *S. schleiferi* showed weak positive results and all other (100/100) strains were negative.

**Reproducibility**

A reproducibility study was performed on 10 isolates in triplicate on three separate days at three separate sites. The following tables present the results of the reproducibility study; by site across three days of testing and by day across the three sites, respectively.

**Summary of Reproducibility Results by Site Across 3 Days**

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<thead>
<tr>
<th>Site 1</th>
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<tr>
<td>Negative Agreement</td>
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<tr>
<td>Total Agreement</td>
<td>100% (90/90)</td>
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**Summary of Reproducibility Results by Day Across 3 Sites**

<table>
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<tr>
<th>Day 1</th>
<th>Day 2</th>
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<td>36/36</td>
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<tr>
<td>Negative Agreement</td>
<td>54/54</td>
<td>54/54</td>
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<tr>
<td>Total Agreement</td>
<td>100% (90/90)</td>
<td>100% (90/90)</td>
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**Bibliography**


**Definitions**

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<td>Authorized representative</td>
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<tr>
<td>Use by</td>
<td>Environment</td>
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</tbody>
</table>

**Technical Advice and Customer Service**

For all inquiries, please contact OpGen or your local distributor.

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27 March 2018  
PN1677-EN  
DCN 26-18