

**510(k) SUBSTANTIAL EQUIVALENCE DETERMINATION  
DECISION MEMORANDUM**

**A. 510(k) Number:**

K151589

**B. Purpose for Submission:**

To obtain clearance for a new device, BD MAX™ CT/GC/TV on BD MAX™ System

**C. Measurand:**

*Chlamydia trachomatis*, *Neisseria gonorrhoeae*, and *Trichomonas vaginalis* DNA

**D. Type of Test:**

Nucleic acid amplification assay (real-time polymerase chain reaction)

**E. Applicant:**

Becton, Dickinson and Company

**F. Proprietary and Established Names:**

BD MAX™ CT/GC/TV  
BD MAX™ System

**G. Regulatory Information:**

1. Regulation section:

21 CFR 866.3860 - *Trichomonas vaginalis* nucleic acid assay  
21 CFR 866.3120 - *Chlamydia* serological reagents  
21 CFR 866.3390 - *Neisseria* spp. direct serological test reagents

2. Classification:

Class II

3. Product code:

OUY: *Trichomonas vaginalis* Nucleic Acid Amplification Test System  
MKZ - DNA Probe, Nucleic Acid Amplification, *Chlamydia*  
LSL - DNA-Reagents, *Neisseria*  
NSU - Instrumentation for Clinical Multiplex Test Systems

4. Panel:

Microbiology (83)

**H. Intended Use:**

1. Intended use(s):

The BD MAX CT/GC/TV assay, as performed using the BD MAX System incorporates automated DNA extraction and real-time polymerase chain reaction (PCR) for the direct, qualitative detection of DNA from *Chlamydia trachomatis* (CT), *Neisseria gonorrhoeae* (GC) and/or *Trichomonas vaginalis* (TV). The assay may be used for detection of CT and/or GC DNA in male urine specimens, and the detection of CT, GC and/or TV DNA in female urine specimens, clinician-collected female endocervical swab specimens and patient-collected vaginal swab specimens (in a clinical setting). The assay is indicated for use to aid in the diagnosis of chlamydial urogenital disease, gonococcal urogenital disease and/or trichomoniasis in asymptomatic and symptomatic individuals.

2. Indication(s) for use:

Same as the Intended Use

3. Special conditions for use statement(s):

For prescription use only

4. Special instrument requirements:

BD MAX™ System

**I. Device Description:**

The BD MAX™ System and the BD MAX™ CT/GC/TV are comprised of an instrument with associated hardware and accessories, disposable microfluidic cartridges, master mixes, unitized reagent strips, and extraction reagents. These components are used to extract, amplify, and detect DNA using real-time PCR. This process is fully automated and requires user intervention only for loading and unloading samples. The BD MAX™ System software automatically interprets test results. For the BD MAX™ CT/GC/TV, a test result may be called as POS (positive), NEG (negative) or UNR (unresolved) for each of the assay's targets, based on the amplification status of the target and of the Sample Processing Control (SPC), present in the Extraction Tube. IND (Indeterminate) or INC (Incomplete) results are due to BD MAX™ System failure.

**J. Substantial Equivalence Information:**

1. Predicate device name(s):

BD ProbeTec™ *Chlamydia trachomatis* (CT) Q<sup>x</sup> Amplified DNA Assay  
 BD ProbeTec™ *Neisseria gonorrhoeae* (GC) Q<sup>x</sup> Amplified DNA Assay  
 BD ProbeTec™ *Trichomonas vaginalis* (TV) Q<sup>x</sup> Amplified DNA Assay

2. Predicate 510(k) number(s):

K081824  
 K081825  
 K130268

3. Comparison with predicate:

Item	Device (K151589)	Predicate (K081824)	Predicate (K081825)	Predicate (K130268)
Intended Use	The BD MAX CT/GC/TV assay, as performed using the BD MAX System incorporates automated DNA extraction and real-time polymerase chain reaction (PCR) for the direct, qualitative detection of DNA from <i>Chlamydia trachomatis</i> (CT), <i>Neisseria gonorrhoeae</i> (GC) and/or <i>Trichomonas vaginalis</i> (TV). The assay may be used for detection of CT and/or GC DNA in male urine specimens, and the detection of CT, GC, and/or TV DNA in female urine specimens, clinician-collected female endocervical swab specimens and patient-	The BD ProbeTec <i>Chlamydia trachomatis</i> Q <sup>x</sup> Amplified DNA Assay, when tested with either the BD Viper™ System in Extracted Mode or the BD Viper LT System, uses Strand Displacement Amplification technology for the direct, qualitative detection of <i>Chlamydia trachomatis</i> DNA in clinician collected female endocervical and male urethral swab specimens, patient-collected vaginal swab specimens (in a clinical setting), and male and female urine specimens (both UPT and neat).	The BD ProbeTec™ <i>Neisseria gonorrhoeae</i> Q <sup>x</sup> Amplified DNA Assay, when tested with either the BD Viper™ System in Extracted Mode or the BD Viper LT™ System, uses Strand Displacement Amplification technology for the direct, qualitative detection of <i>Neisseria gonorrhoeae</i> DNA in clinician-collected female endocervical and male urethral swab specimens, patient-collected vaginal swab specimens (in a clinical setting), and male and female urine specimens (both UPT and Neat).	The BD ProbeTec™ <i>Trichomonas vaginalis</i> (TV) Q <sup>x</sup> Amplified DNA Assay, when tested with the BD Viper™ System in Extracted Mode, uses Strand Displacement Amplification technology for the direct, qualitative detection of <i>Trichomonas vaginalis</i> DNA in clinician-collected female endocervical swab specimens, patient-collected vaginal swab specimens (in a clinical setting), and female urine specimens. The assay is indicated for use with asymptomatic and symptomatic females to aid in

Item	Device (K151589)	Predicate (K081824)	Predicate (K081825)	Predicate (K130268)
	collected vaginal swab specimens (in a clinical setting). The assay is indicated for use to aid in the diagnosis of chlamydial urogenital disease, gonococcal urogenital disease and/or trichomoniasis in asymptomatic and symptomatic individuals.	The assay is also intended for use with gynecological specimens collected in BD SurePath™ Preservative Fluid or PreservCyt™ Solution using an aliquot that is removed prior to processing for either the BD SurePath or ThinPrep™ Pap test. The assay is indicated for use with asymptomatic and symptomatic individuals to aid in the diagnosis of chlamydial urogenital disease.	The assay is also intended for use with gynecological specimens collected in BD SurePath™ Preservative Fluid or PreservCyt™ Solution using an aliquot that is removed prior to processing for either the BD SurePath or ThinPrep™ Pap test. The assay is indicated for use with asymptomatic and symptomatic individuals to aid in the diagnosis of gonococcal urogenital disease.	the diagnosis of trichomoniasis.
Assay Results	Qualitative	Qualitative	Qualitative	Qualitative
Organisms Detected	CT/GC/TV	CT	GC	TV
Instrument	BD MAX™ System	BD Viper™ System	BD Viper™ System	BD Viper™ System
Technology	Real-time PCR	SDA (Strand displacement amplification)	SDA	SDA
Specimens	Endocervical swab, patient-collected vaginal swab, female and male urine	Endocervical swab, patient-collected vaginal swab, male urethral swab, male and female urine (UPT and neat)	Endocervical swab, patient-collected vaginal swab, male urethral swab, male and female urine (UPT and neat)	Endocervical swab, patient-collected vaginal swab, female urine

## **K. Standard/Guidance Document Referenced (if applicable):**

Establishing the Performance Characteristics of In Vitro Diagnostic Devices for *Chlamydia trachomatis* and/or *Neisseria gonorrhoea*: Screening and Diagnostic Testing - Draft Guidance for Industry and FDA Staff, May 11, 2011.

MM03-A2, 2006 – Molecular Diagnostic Methods for Infectious Diseases, CLSI Approved Guideline

EP12-A2, 2008 – User protocol for Evaluation of Qualitative Test performance, CLSI Approved Guideline

M29 – Protection of laboratory workers from occupationally acquired infections, CLSI Approved Guideline

## **L. Test Principle:**

The BD MAX<sup>TM</sup> CT/GC/TV assay on BD MAX<sup>TM</sup> System consists of automated DNA extraction and real-time PCR for the qualitative detection of CT/GC/TV DNA from the urogenital specimens. The specimen collected using the BD MAX UVE Specimen Collection Kit is vortexed briefly and then heated on the BD Pre-warm Heater to dissolve mucous, homogenize the specimen matrix and lyse the target organisms. A worklist is created and the BD MAX UVE Sample Buffer Tube, the BD MAX<sup>TM</sup> CT/GC/TV Unitized Reagent Strip, and the BD MAX PCR Cartridge are loaded on the BD MAX<sup>TM</sup> System. The BD MAX<sup>TM</sup> System automates sample preparation, including target organism lysis, DNA extraction and concentration, reagent rehydration, and target nucleic acid amplification and detection using real-time PCR. The BD MAX<sup>TM</sup> System performs results interpretation automatically.

Following cell lysis, the released nucleic acids are captured on magnetic affinity beads, washed, eluted, neutralized, and transferred to the Master Mix to rehydrate the PCR reagents. After reconstitution, the BD MAX<sup>TM</sup> System dispenses a fixed volume of PCR-ready solution containing extracted nucleic acids into the BD MAX PCR Cartridge. Microvalves in the BD MAX PCR Cartridge are sealed by the system prior to initiating PCR to contain the amplification mixture, thus preventing evaporation and contamination. The amplified DNA targets are detected using hydrolysis (TaqMan®) probes, labeled at one end with a fluorescent reporter dye (fluorophore), and at the other end, with a quencher moiety. Probes labeled with different fluorophores are used to detect amplicons for target analytes and the Sample Processing Control in four different optical channels of the BD MAX<sup>TM</sup> System. When the probes are in their native state, the fluorescence of the fluorophore is quenched due to its proximity to the quencher. In the presence of target DNA, the probes hybridize to their complementary sequences and are hydrolyzed by the 5'-3' exonuclease activity of the DNA polymerase as it synthesizes the nascent strand along the DNA template. As a result, the fluorophores are separated from the quencher molecules and fluorescence is emitted. The BD MAX<sup>TM</sup> System monitors these signals at each cycle and interprets the data at the end of the reaction to provide qualitative test results for each analyte.

**M. Performance Characteristics (if/when applicable):**

1. Analytical performance:

a. *Precision*

Within-laboratory precision was evaluated for the BD MAX™ CT/GC/TV assay at one site. Testing was performed over 12 days, with 2 runs per day (2 technologists, alternating operators each day), for a total of 24 runs. Each panel contained vaginal swab or female urine specimen matrix and included *Chlamydia trachomatis*, *Neisseria gonorrhoeae* and *Trichomonas vaginalis* panel members. The following concentrations were used as spike levels for the target organisms contained in each panel member:

- Moderate Positive (MP): 3x LoD
- Low Positive (LP): 1.5x LoD
- High Negative (HN): <1x LoD
- True negative (TN): no target

Precision study results for the BD MAX CT/GC/TV are described in Table 1.

Table 1: Overall Precision Study Results Using One Lot of the BD MAX CT/GC/TV

Panel Member Level	Percent (%) Observed versus Expected					
	<i>C. trachomatis</i>		<i>N. gonorrhoeae</i>		<i>T. vaginalis</i>	
	<i>Swab</i>	<i>Urine</i>	<i>Swab</i>	<i>Urine</i>	<i>Swab</i>	<i>Urine</i>
<i>True Negative</i>	100% (336/336) 98.9-100	100% (336/336) 98.9-100	100% (48/48) 92.6-100	100% (336/336) 98.9-100	100% (336/336) 98.9-100	100% (48/48) 92.6-100
<i>High Negative</i>	79.2% (38/48) 65.7-88.3	79.2% (38/48) 65.7-88.3	54.2% (26/48) 40.3-67.4	10.4% (5/48) 4.5-22.2	56.3% (27/48) 42.3-69.3	14.6% (7/48) 7.2-27.2
<i>Low Positive</i>	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100	97.9% (47/48) 89.1-99.6	100% (48/48) 92.6-100
<i>Moderate Positive</i>	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100	100% (48/48) 92.6-100

<sup>a</sup> For the True Negative (TN) category, the reported agreement indicates the percent of negative results.

<sup>b</sup> For the High Negative (HN) category, the reported agreement indicates the percent of positive results.

*b. Reproducibility*

Site-to-Site reproducibility of the BD MAX™ CT/GC/TV assay was evaluated at three sites (two external and one internal). Each site was provided the same panels as described for the Precision study, above. The testing was performed on eight distinct days (consecutive or not), wherein each day, two panels were tested by one technologist (alternating operators each day). The overall Site-to-Site Reproducibility percent agreement for all targets ranged from 99.9% to 100% for the TN samples, 15.6% to 78.1% for the HN samples, 96.9% to 100% for the LP samples, and 100% for the MP samples (Table 2).

Table 2: MAX CT/GC/TV Site-to-Site Reproducibility Study Results

Category	Percent Observed versus Expected					
	<i>C. trachomatis</i> (n), 95% CI		<i>N. gonorrhoeae</i> (n), 95% CI		<i>T. vaginalis</i> (n), 95% CI	
	Swab	Urine	Swab	Urine	Swab	Urine
TN	100% (672/672) 99.4-100	99.9% (671/672) 99.2-100	100% (96/96) 96.2-100	100% (672/672) 99.4-100	100% (672/672) 99.4-100	100% (96/96) 96.2-100
HN	78.1% (75/96) 68.9-85.2	75.0% (72/96) 65.5-82.6	55.2% (53/96) 45.3-64.8	15.6% (15/96) 9.7-24.2	52.1% (50/96) 42.2-61.8	35.4% (34/96) 26.6-45.4
LP	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100	96.9% (93/96) 91.2-98.9	100% (96/96) 96.2-100
MP	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100	100% (96/96) 96.2-100

The qualitative reproducibility across sites and by target is presented below in Tables 3 - 5.

Table 3: *Chlamydia trachomatis* Site-to-Site Qualitative Reproducibility

Category	Type	x LoD	Site						Total	
			1		2		3			
			Agree/N	%	Agree/N	%	Agree/N	%	Agree/N	%
TN	Swab	0	224/224	100	224/224	100	224/224	100	672/672	100
	Urine		223/224	99.6	224/224	100	224/224	100	671/672	99.9
HN	Swab	0.2	29/32	90.6	21/32	65.6	25/32	78.1	75/96	78.1
	Urine		28/32	87.5	20/32	62.5	24/32	75.0	72/96	75.0
LP	Swab	1.5	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100
MP	Swab	3	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100

Table 4: *N. gonorrhoeae* Site-to-Site Qualitative Reproducibility

Category	Type	x LoD	Site						Total	
			1		2		3		Agree/N	%
			Agree/N	%	Agree/N	%	Agree/N	%		
TN	Swab	0	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		224/224	100	224/224	100	224/224	100	672/672	100
HN	Swab	0.15	16/32	50.0	15/32	46.9	22/32	68.8	53/96	55.2
	Urine	0.25	8/32	25.0	3/32	9.4	4/32	12.5	15/96	15.6
LP	Swab	1.5	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100
MP	Swab	3	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100

Table 5: *T. vaginalis* Site-to-Site Qualitative Reproducibility

Category	Type	x LoD	Site						Total	
			1		2		3		Agree/N	%
			Agree/N	%	Agree/N	%	Agree/N	%		
TN	Swab	0	224/224	100	224/224	100	224/224	100	672/672	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100
HN	Swab	0.25	15/32	46.9	15/32	46.9	20/32	62.5	50/96	52.1
	Urine	0.05	4/32	12.5	19/32	59.4	11/32	34.4	34/96	35.4
LP	Swab	1.5	30/32	93.8	31/32	96.9	32/32	100	93/96	96.9
	Urine		32/32	100	32/32	100	32/32	100	96/96	100
MP	Swab	3	32/32	100	32/32	100	32/32	100	96/96	100
	Urine		32/32	100	32/32	100	32/32	100	96/96	100

For the Lot-to-Lot reproducibility study, two operators each completed a single run of 10 panel members on a single instrument for each of three lots of reagents over an 8-day period. The panels used were the same as described in the Precision study. The overall Lot-to-Lot reproducibility percent agreement across all targets ranged from 99.9% to 100%, 29.2% to 72.9%, and 100% for the TN, HN, LP and MP categories, respectively (Table 6).

Table 6: Lot-to-Lot Reproducibility

Target	Type	Level	Correct	Total	% Correct	95% CI
<i>Chlamydia trachomatis</i>	Swab	TN**	672	672	100	(99.4-100)
		HN*	70	96	72.9	(63.3-80.8)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)

	Urine	TN	672	672	100	(99.4-100)
		HN	70	96	72.9	(63.3-80.8)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)
<i>Neisseria gonorrhoeae</i>	Swab	TN	96	96	100	(96.2-100)
		HN	40	96	41.7	(32.3-51.7)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)
	Urine	TN	672	672	100	(99.4-100)
		HN	44	96	45.8	(36.2-55.8)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)
<i>Trichomonas vaginalis</i>	Swab	TN	671	672	99.9	(99.2-100)
		HN	56	96	58.3	(48.3-67.7)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)
	Urine	TN	96	96	100	(96.2-100)
		HN	28	96	29.2	(21.0-38.9)
		LP	96	96	100	(96.2-100)
		MP	96	96	100	(96.2-100)

\*HNs are dilutions of analytes at the LoD designed to produce results that are negative for 5% to 85% of replicates. As such, “% Correct” correlates to the percent of negative results.

\*\* TNs did not contain any analyte, therefore, “% Correct” correlates to the percent of negative results

c. *Linearity/assay reportable range:*

Not applicable

d. *Traceability, Stability, Expected values (controls, calibrators, or methods):*

Controls:

External controls are not provided by the manufacturer. Commercially available control material may be used as positive control, e.g., *Chlamydia trachomatis* serovar H (ATCC™ VR-879), *Neisseria gonorrhoeae* (ATCC 19424), *Trichomonas vaginalis* (ATCC 30001) or a previously characterized clinical sample known to be positive. BD MAX UVE Sample Buffer Tube without the addition of organism or a previously characterized sample known to be negative is recommended for use as an external negative control. External positive and negative controls were included in all analytical and clinical studies performed in support of this submission.

The BD MAX™ CT/GC/TV assay includes a Sample Processing Control (SPC) which is present in the Extraction Tube and monitors DNA extraction steps, thermal cycling steps, reagent integrity and the presence of inhibitory substances.

Specimen Stability Studies:

First void urine specimens must be transferred from the collection cup to the BD MAX UVE Sample Buffer Tube within 4 hours of collection when kept at 2-30 °C or within 24 hours of collection when stored at 2-8 °C. Clinician-collected endocervical swab and patient-collected vaginal swab specimens must be transferred immediately or within two hours after collection to the BD MAX UVE Sample Buffer Tube when kept at 2-30 °C (Table 7).

Table 7: Specimen Stability Prior to Transfer into the BD MAX UVE Sample Buffer Tube

Specimen Stability	Specimen Type	Transport and/or Storage Temperature	
		2-30°C	2-8°C
Prior to Transfer into BD MAX UVE Sample Buffer Tube	Urine	4 hours	24 hours
	Vaginal/Endocervical Swab	2 hours	2 hours

Urine or swab sample in BD MAX UVE Sample Buffer Tubes can be transported and stored for up to 5 days at 2-30 °C or up to 30 days at -20 °C prior to pre-warm (Table 8).

Table 8: Sample Stability in BD MAX UVE Sample Buffer Tube Prior to Pre-Warm

Sample Stability	Specimen Type	Transport and/or Storage Temperature	
		2-30°C	-20°C
In BD MAX UVE Sample Buffer Tube	Urine, Vaginal/Endocervical Swab	5 days	30 days

Once pre-warmed, samples previously stored at the 2-30 °C condition can be stored for an additional 5 days at 2-30 °C or an additional 30 days at -20 °C before testing on the BD MAX System (Table 9). Once pre-warmed, samples previously stored at the -20 °C condition can be stored for an additional 5 days at -20 or 2-30 °C before testing on the BD MAX System.

Combined sample stability (prior to pre-warm and post pre-warm) can not exceed a total of 35 days.

Table 9: Sample Stability in BD MAX UVE Sample Buffer Tube Post Pre-Warm

Sample Stability	Specimen Type	Storage Temperature	
		2-30°C	-20°C
Post Pre-warm (previously stored 2-30 °C)	Urine, Vaginal/Endocervical Swab	5 days	30 days
Post Pre-warm (previously stored -20 °C)	Urine, Vaginal/Endocervical Swab	5 days	5 days

e. *Detection limit:*

The Limit of Detection (LoD) for the BD MAX™ CT/GC/TV assay in urine and vaginal swab specimen matrix was determined by testing two representative strains for each of the target organisms detected by the BD MAX CT/GC/TV assay. Each target organism was prepared and quantified prior to testing. Positive specimens were prepared by inoculating pooled female urine and pooled vaginal swab matrix in BD MAX UVE Sample Buffer and tested at multiple concentrations of each representative strain. Each matrix suspension was tested with at least 20 replicates per LoD concentration using at least 6 BD MAX Systems and 3 different production lots of the BD MAX CT/GC/TV assay. Analytical sensitivity (LoD) was defined as the lowest concentration at which 95% of all replicates tested positive. The LODs for urine and vaginal swab matrices are presented in Table 10 below.

Table 10: Limit of Detection by the BD MAX CT/GC/TV

Organism	Strain	Specimen	LoD Concentration (units/mL) <sup>a</sup>
<i>Chlamydia trachomatis</i>	Serovar H	Urine	11
		Vaginal Swab	9
	Serovar D	Urine	5
		Vaginal Swab	13
<i>Neisseria gonorrhoeae</i>	ATCC 19424	Urine	60
		Vaginal Swab	60
	ATCC 49226	Urine	181
		Vaginal Swab	117
<i>Trichomonas vaginalis</i>	ATCC 30001	Urine	10
		Vaginal Swab	5
	ATCC 50143	Urine	34
		Vaginal Swab	10

<sup>a</sup>Units/mL LoD concentration represented in Elementary Bodies (EB)/mL for *Chlamydia trachomatis*, cells/mL for *Neisseria gonorrhoeae* and TV/mL for *Trichomonas vaginalis*.

The BD MAX CT/GC/TV assay detected 95% or greater proportion of positive samples with 15 additional *Chlamydia trachomatis* serovars (A, B, Ba, C, E, vE, F, G, I, J, K, L1, L2, L2a, and L3), 30 *Neisseria gonorrhoeae* strains and 8 *Trichomonas vaginalis* strains (ATCC 30092, 30184, 30185, 30187, 30236, 30237, 30235, and 30186). These 53 serovars/strains represented public collections and well-characterized clinical isolates and were inoculated at 1X LoD in BD MAX UVE

Sample Buffer and tested with both pooled female urine and pooled vaginal swab specimens. The BD MAX CT/GC/TV assay correctly identified 51 of the serovars/strains tested for urine specimens and 49 of the serovars/strains tested for vaginal swab specimens upon initial testing. Three strains of *Trichomonas vaginalis* and one serovar of *Chlamydia trachomatis* in vaginal swab specimen, in addition to two strains of *Neisseria gonorrhoeae* in urine, did not meet acceptance criteria and were further evaluated. Of the six strains further evaluated, one was confirmed at 2X LoD and five were confirmed at 1X LoD.

*f. Analytical specificity:*

The BD MAX CT/GC/TV assay was performed on samples containing phylogenetically related species and other microorganisms likely to be found in urogenital specimens. The bacteria, yeasts, viruses, and parasites were tested in the BD MAX UVE Sample Buffer Tube at  $1 \times 10^6$  cells/mL, genomic DNA cp/mL, and viruses were tested at  $1 \times 10^5$  viral particles or genomic equivalents/mL. Organisms tested are represented below in Table 11.

Of all microorganisms tested 98% (168/170) produced negative results with the BD MAX CT/GC/TV. No cross-reaction was observed for *Chlamydia trachomatis* or *Neisseria gonorrhoeae*.

*Pentatrichomonas hominis* (commensal of the large intestine) produced positive results at a concentration  $\geq 3.39 \times 10^5$  organisms/mL for *Trichomonas vaginalis* and negative results for all other targets with the BD MAX™ CT/GC/TV assay.

*Trichomonas tenax* (commensal of the oral cavity) produced positive results at a concentration  $\geq 10$  organisms/mL for *Trichomonas vaginalis* and negative results for all other targets with the BD MAX CT/GC/TV assay. These limitations are included in the labeling.

Table 11: BD MAX CT/GC/TV Specificity Results (Bacteria, Yeasts, & Viruses)

Organism	Organism	Organism
<i>Achromobacter xerosis</i>	<i>Gamella haemolysans</i>	<i>Neisseria subflava</i> (14) <sup>a</sup>
<i>Acinetobacter calcoaceticus</i>	<i>Gardnerella vaginalis</i>	<i>Paracoccus denitrificans</i>
<i>Acinetobacter lwoffii</i>	<i>Haemophilus ducreyi</i>	<i>Pentatrichomonas hominis</i>
<i>Actinomyces israelii</i>	<i>Haemophilus influenzae</i>	<i>Peptostreptococcus anaerobius</i>
<i>Actinomyces pyogenes</i>	Herpes Simplex Virus 1	<i>Peptostreptococcus productus</i>
<i>Aerococcus viridans</i>	Herpes Simplex Virus 2	<i>Plesiomonas shigelloides</i>
<i>Aeromonas hydrophilia</i>	HPV 16	<i>Propionibacterium acnes</i>
<i>Agrobacterium radiobacter</i>	HPV 18	<i>Proteus mirabilis</i>
<i>Alcaligenes faecalis</i>	HPV 6	<i>Proteus vulgaris</i>
<i>Bacillus subtilis</i>	HPV11	<i>Providencia stuartii</i>
<i>Bacteriodes ureolyticum</i>	<i>Kingella kingae</i>	<i>Pseudomonas aeruginosa</i>
<i>Bacteroides fragilis</i>	<i>Klebsiella oxytoca</i>	<i>Pseudomonas fluorescens</i>
<i>Bifidobacterium adolescentis</i>	<i>Klebsiella pneumoniae</i>	<i>Pseudomonas putida</i>
<i>Bifidobacterium brevis</i>	<i>Lactobacillus adicophilus</i>	<i>Rahnella aquatilis</i>
<i>Branhamella catarrhalis</i>	<i>Lactobacillus brevis</i>	<i>Rhodospirillum rubrum</i>
<i>Brevibacterium linens</i>	<i>Lactobacillus jensenii</i>	<i>Saccharomyces cerevisiae</i>

Organism	Organism	Organism
<i>Campylobacter jejuni</i>	<i>Lactobacillus lactis</i>	<i>Salmonella Minnesota</i>
<i>Candida albicans</i>	<i>Legionella pneumophila</i> (2) <sup>a</sup>	<i>Salmonella typhimurium</i>
<i>Candida glabrata</i>	<i>Leuconostoc paramensenteroides</i>	<i>Serratia marcescens</i>
<i>Candida parapsilosis</i>	<i>Listeria monocytogenes</i>	<i>Staphylococcus aureus</i> , non Protein A
<i>Candida tropicalis</i>	<i>Micrococcus leutus</i>	<i>Staphylococcus aureus</i> , Protein A
<i>Chlamydia pneumoniae</i>	<i>Moraxella lacunata</i>	<i>Staphylococcus epidermidis</i>
<i>Chlamydia psittaci</i> (2) <sup>a</sup>	<i>Moraxella osloensis</i>	<i>Staphylococcus saprophyticus</i>
<i>Chlamydia trachomatis</i> Serovar H <sup>b</sup>	<i>Morganella morganii</i>	<i>Streptococcus agalactiae</i> (Grp B)
<i>Chromobacterium violaceum</i>	<i>Mycobacterium smegmatis</i>	<i>Streptococcus bovis</i>
<i>Citrobacter freundii</i>	<i>Mycoplasma genitalium</i>	<i>Streptomyces griseus</i>
<i>Clostridium perfringens</i>	<i>Mycoplasma hominis</i>	<i>Streptococcus mitis</i>
<i>Corynebacterium genitalium</i> biovar 1	<i>Neisseria cinerea</i> (3) <sup>a</sup>	<i>Streptococcus mutans</i>
<i>Corynebacterium xerosis</i>	<i>Neisseria denitrificans</i>	<i>Streptococcus pneumoniae</i>
<i>Cryptococcus neoformans</i>	<i>Neisseria elongata</i> (3) <sup>a</sup>	<i>Streptococcus pyogenes</i> (Grp A)
<i>Cytomegalovirus</i>	<i>Neisseria flava</i>	<i>Streptococcus salivarius</i>
<i>Deinococcus radiodurans</i>	<i>Neisseria flavescens</i> (2) <sup>a</sup>	<i>Streptococcus sanguis</i>
<i>Derxia gummosa</i>	<i>Neisseria gonorrhoeae</i> (3) <sup>a, b</sup>	<i>Trichomonas vaginalis</i> <sup>b</sup>
<i>Eikenella corrodens</i>	<i>Neisseria lactamica</i> (9) <sup>a</sup>	<i>Trichomonas tenax</i>
<i>Enterobacter aerogenes</i>	<i>Neisseria meningitidis</i> A (4) <sup>a</sup>	<i>Ureaplasma urealyticum</i>
<i>Enterobacter cloacae</i>	<i>Neisseria meningitidis</i> B (2) <sup>a</sup>	<i>Vibrio parahaemolyticus</i>
<i>Enterococcus avium</i>	<i>Neisseria meningitidis</i> C (5) <sup>a</sup>	<i>Yersinia enterocolitica</i>
<i>Enterococcus faecalis</i>	<i>Neisseria meningitidis</i> D	
<i>Enterococcus faecium</i>	<i>Neisseria meningitidis</i> W135	
<i>Erwinia herbicola</i> ( <i>Escherichia vulneris</i> )	<i>Neisseria meningitidis</i> Y	
<i>Erysipelothrix rhusiopathiae</i>	<i>Neisseria mucosa</i> (3) <sup>a</sup>	
<i>Escherichia coli</i>	<i>Neisseria perflava</i> (4) <sup>a</sup>	
<i>Flavobacterium meningosepticum</i>	<i>Neisseria polysaccharea</i>	
<i>Fuseobacterium nucleatum</i>	<i>Neisseria sicca</i> (4) <sup>a</sup>	

<sup>a</sup> The number in parenthesis indicates the number of strains tested.

<sup>b</sup> No cross-reactivity observed with the other two BD MAX™ CT/GC/TV analytes

g. Assay cut-off:

Not applicable

2. Comparison studies:

a. *Method comparison with predicate device:*

Not applicable

b. *Matrix comparison:*

Not applicable

3. Clinical studies:

A multi-site (geographically diverse) study was conducted to evaluate the BD MAX™ CT/GC/TV assay. A total of 2166 female subjects and 908 male subjects from OB/GYN, sexually transmitted disease (STD) and family planning clinics were enrolled in the *Chlamydia trachomatis* and *Neisseria gonorrhoeae* assay arm of the study. Of these, 1327 female subjects were enrolled in the *Trichomonas vaginalis* assay arm of the study. The final data analysis included 2114 evaluable female subjects for *Chlamydia trachomatis* and *Neisseria gonorrhoeae*, with 1291 of these female subjects evaluable for *Trichomonas vaginalis*. For males, 892 were evaluable subjects for *Chlamydia trachomatis* and *Neisseria gonorrhoeae* analyses. From these compliant subjects, *Chlamydia trachomatis* performance was calculated from 1836 patient-collected vaginal swab, 1831 endocervical swab, 1849 female urine and 830 male urine specimens. *Neisseria gonorrhoeae* evaluable specimens included 1836 patient-collected vaginal swab, 1824 endocervical swab, 1849 female urine and 840 male urine specimens. *Trichomonas vaginalis* compliant specimens consisted of 1048 patient-collected vaginal swab, 1039 endocervical swab, and 1047 female urine specimens. Exclusions included but are not limited to: enrollment issues, missing specimens, transport errors, collection errors, shipping errors, processing errors, and/or BD MAX™ System operating errors.

Eight specimens were collected from each eligible female subject. Each female study participant provided one urine specimen, one self-collected vaginal swab (collected in a clinical setting for testing on the BD MAX™ CT/GC/TV), three clinician-collected vaginal swab specimens (two for the *Trichomonas vaginalis* reference testing and one for discrepant analysis), and three endocervical swab specimens (for testing on the BD MAX™ CT/GC/TV and the two CT/NG reference tests). Each male study participant provided one urine specimen and one urethral swab specimen.

The performance of the BD MAX™ CT/GC/TV was calculated compared to Patient Infected Status (PIS). PIS included two different commercially available Nucleic Acid Amplification Tests (NAATs) for females and three NAATs for males from at least two different specimen types for *Chlamydia trachomatis* and *Neisseria gonorrhoeae*, and two tests (culture and wet mount) for *Trichomonas vaginalis*. The subject was designated infected with *Chlamydia trachomatis* and/or *Neisseria gonorrhoeae* if at least two different reference NAATs were positive. For

*Trichomonas vaginalis*, the subject was designated infected if at least one of the reference results (wet mount or culture) was positive. Both *Trichomonas vaginalis* reference results were required to be negative to establish a non-infected status.

The sensitivity, and specificity of the BD MAX™ CT/GC/TV for each specimen type by symptom status is presented in Table 12 below .

Table 12: Assay Performance Compared to Patient Infected Status Algorithm

Gender	Spec	Symp	CT		GC		TV	
			%Sens	%Spec	%Sens	%Spec	%Sens	%Spec
Female	Vag Swab	A	100 (51/51) 93.0-100	98.7 (734/744) 97.5-99.3	94.1 (16/17) 73.0-99.0	99.9 (777/778) 99.3-100	93.1 (27/29) 78.0-98.1	97.5 (270/277) 94.9-98.8
		S	98.9 (89/90) 94.0-99.8	98.6 (938/951) 97.7-99.2	96.3 (26/27) 81.7-99.3	99.8 (1012/1014) 99.3-99.9	96.7 (119/123) 91.9-98.7	99.5 (616/619) 98.6-99.8
		ALL	99.3 (140/141) 96.1-99.9	98.6 (1672/1695) 98.0-99.1	95.5 (42/44) 84.9-98.7	99.8 (1789/1792) 99.5-99.9	96.1 (146/152) 91.7-98.2	98.9 (886/896) 98.0-99.4
	Endo Swab	A	94.1 (48/51) 84.1-98.0	99.1 (737/744) 98.1-99.5	94.1 (16/17) 73.0-99.0	100 (777/777) 99.5-100	96.6 (28/29) 82.8-99.4	98.2 (270/275) 95.8-99.2
		S	96.6 (84/87) 90.3-98.8	99.4 (943/949) 98.6-99.7	96.3 (26/27) 81.7-99.3	99.9 (1002/1003) 99.4-100	92.7 (114/123) 86.7-96.1	99.8 (611/612) 99.1-100
		ALL	95.7 (132/138) 90.8-98.0	99.2 (1680/1693) 98.7-99.6	95.5 (42/44) 84.9-98.7	99.9 (1779/1780) 99.7-100	93.4 (142/152) 88.3-96.4	99.3 (881/887) 98.5-99.7
	Urine	A	92.3 (48/52) 81.8-97.0	99.7 (747/749) 99.0-99.9	88.9 (16/18) 67.2-96.9	99.5 (779/783) 98.7-99.8	93.1 (27/29) 78.0-98.1	98.2 (272/277) 95.8-99.2
		S	91.1 (82/90) 83.4-95.4	99.4 (952/958) 98.6-99.7	100 (28/28) 87.9-100	99.9 (1019/1020) 99.4-100	92.8 (116/125) 86.9-96.2	99.8 (615/616) 99.1-100
		ALL	91.5 (130/142) 85.8-95.1	99.5 (1699/1707) 99.1-99.8	95.7 (44/46) 85.5-98.8	99.7 (1798/1803) 99.4-99.9	92.9 (143/154) 87.7-96.0	99.3 (887/893) 98.5-99.7
Male	Urine	A	98.6 (69/70) 92.3-99.7	99.5 (378/380) 98.1-99.9	80.0 (4/5) 37.6-96.4	100 (447/447) 99.1-100	-	-
		S	94.6 (105/111) 88.7-97.5	99.3 (267/269) 97.3-99.8	100 (103/103) 96.4-100	100 (285/285) 98.7-100	-	-
		ALL	96.1 (174/181) 92.2-98.1	99.4 (645/649) 98.4-99.8	99.1 (107/108) 94.9-99.8	100 (732/732) 99.5-100	-	-

<sup>1</sup> 6 out 12 CT false negative urine samples were also negative on NAAT1 and NAAT2

<sup>2</sup> 1 out 2 GC false negative urine samples were also negative on NAAT1 and NAAT2

Rate of non-reportable results:

Unresolved results

Of the 6573 specimens initially evaluated with the BD MAX<sup>TM</sup> CT/GC/TV, 1.6% of patient-collected vaginal swab, 1.8% of endocervical swab and 1.5% of urine specimens were initially reported as Unresolved. Following a valid repeat test, 0.5% of patient-collected vaginal swab, 0.8% of endocervical swab and 0.4% of urine specimens remained Unresolved (Table 13).

Table 13: Rates of Unresolved Results

Specimen Type	Initial Unresolved Rate		Final Unresolved Rate with Valid Repeat	
	Estimate	95% CI	Estimate	95% CI
Vaginal Swab	1.6% (31/1910)	(1.1%, 2.3%)	0.5% (9/1908)	(0.2%, 0.9%)
Endocervical	1.8% (34/1907)	(1.3%, 2.5%)	0.8% (16/1903)	(0.5%, 1.4%)
Urine	1.5% (41/2756)	(1.1%, 2.0%)	0.4% (11/2752)	(0.2%, 0.7%)

Indeterminate results

Of the 6573 specimens initially evaluated with the BD MAX<sup>TM</sup> CT/GC/TV, 0.9% of patient-collected vaginal swab, 0.4% of endocervical swab and 0.9% of urine specimens were initially reported as Indeterminate. Following a valid repeat test, 0.3% of patient-collected vaginal swab, 0.1% of endocervical swab and 0.2% of urine specimens remained Indeterminant (Table 14).

Table 14: Rates of Indeterminate Results

Specimen Type	Initial Indeterminate Rate		Final Indeterminate Rate with Valid Repeat	
	Percent	95% CI	Per	95% CI
Vaginal Swab	0.9% (17/1910)	(0.6%, 1.4%)	0.3% (5/1908)	(0.1%, 0.6%)
Endocervical	0.4% (8/1907)	(0.2%, 0.8%)	0.1% (2/1902)	(0.0%, 0.4%)
Urine	0.9% (25/2756)	(0.6%, 1.3%)	0.2% (5/2752)	(0.1%, 0.4%)

Incomplete results

Of the 6573 specimens initially evaluated with the BD MAX<sup>TM</sup> CT/GC/TV, 1.7% of patient-collected vaginal swab, 1.7% of endocervical swab and 1.9% of urine specimens initially reported as Incomplete. Following a valid repeat test, 0.1% of patient-collected vaginal swab, 0.1% of endocervical swab and 0.1% of urine specimens remained Incomplete (Table 15).

Table 15: Rates of Indeterminate Results

Specimen Type	Initial Incomplete Rate		Final Incomplete Rate with Valid Repeat	
	Estimate	95% CI	Estimate	95% CI
Vaginal Swab	1.7% (33/1910)	(1.2%, 2.4%)	0.1% (1/1908)	(0.0%, 0.3%)
Endocervical	1.7% (32/1907)	(1.2%, 2.4%)	0.1% (1/1902)	(0.0%, 0.3%)
Urine	1.9% (52/2756)	(1.4%, 2.5%)	0.1% (2/2752)	(0.0%, 0.3%)

Table 16: Total Unresolved, Indeterminate, and Incomplete results

Specimen Type	Initial Non-Reportable Rate		Final Non-Reportable Rate with Valid Repeat	
	Estimate	95% CI	Estimate	95%
Vaginal	4.2% (81/1910)	(3.4%, 5.2%)	0.8% (15/1908)	(0.5%, 1.3%)
Endocervical	3.9% (74/1907)	(3.1%, 4.8%)	1.0% (19/1902)	(0.6%, 1.6%)
Urine	4.3% (118/2756)	(3.6%, 5.1%)	0.7% (18/2752)	(0.4%, 1.0%)
Overall	4.2% (273/6573)	(3.7%, 4.7%)	0.8% (52/6562)	(0.6%, 1.0%)

4. Clinical cut-off:

Not applicable

5. Expected values/Reference range:

The prevalence of infection with CT and/or NG, and/or TV in patient populations depends on risk factors such as age, gender, the presence or absence of symptoms, the type of clinic, and the sensitivity of the test used to detect infections. During the clinical evaluation of the BD MAX™ CT/NG/TV, the observed CT prevalence rates in females and males were 7.6% and 21.2%, respectively. The observed NG prevalence rates in females and males were 2.6% and 12.6%, respectively. The observed TV prevalence rate in females was 14.6%.

Positive and Negative Predictive Values

Hypothetical estimated positive and negative predictive values (PPV and NPV) for different prevalence rates using the BD MAX™ CT/NG/TV are shown in tables 17 – 19 below. These calculations are based on the hypothetical prevalence and overall sensitivity and specificity compared to the PIS.

Table 17: Hypothetical PPV and NPV for CT compared to PIS

Prevalenc	Sensitivity	Specificity	PPV	NPV
1%	95.7% (576/602)	99.2% (5696/5744)	53.6%	100%
2%			70.0%	99.9%
5%			85.8%	99.8%
10%			92.7%	99.5%
20%			96.6%	98.9%
30%			98.0%	98.2%
40%			98.7%	97.2%
50%			99.1%	95.8%

Table 18: Hypothetical PPV and NPV for GC compared to PIS

Prevalenc	Sensitivity	Specificity	PPV	NPV
1%	97.1% (235/242)	99.9% (6098/6107)	86.9%	100.0%
2%			93.1%	99.9%
5%			97.2%	99.8%
10%			98.7%	99.7%
20%			99.4%	99.3%
30%			99.6%	98.8%
40%			99.8%	98.1%
50%			99.8%	97.2%

Table 19: Hypothetical PPV and NPV for TV compared to PIS

Prevalenc	Sensitivity	Specificity	PPV	NPV
1%	94.1% (431/458)	99.2% (2654/2676)	53.6%	99.9%
2%			70.0%	99.9%
5%			85.8%	99.7%
10%			92.7%	99.3%
20%			96.6%	98.5%
30%			98.0%	97.5%
40%			98.7%	96.2%
50%			99.1%	94.4%

**N. Instrument Name:**

BD MAX™ System

**O. System Descriptions:**

1. Modes of Operation:

Does the applicant's device contain the ability to transmit data to a computer, webserver, or mobile device?

Yes  or No

Does the applicant's device transmit data to a computer, webserver, or mobile device using wireless transmission?

Yes  or No

2. Software:

FDA has reviewed applicant's Hazard Analysis and software development processes for this line of product types:

Yes  or No

3. Specimen Identification:

Specimens are labeled with a unique bar code and following the BD MAX Specimen collection Kit package insert.

4. Specimen Sampling and Handling:

Specimens are collected using the BD MAX™ UVE Specimen Collection kit. The samples in BD MAX™ UVE Sample Buffer Tube are vortexed briefly and are loaded on the BD Pre-Warm Heater. After the pre-warm step the sample tubes are recapped with piercable blue septum cap and placed on the BD MAX™ System rack.

5. Calibration:

System requires preventative maintenance biyearly.

6. Quality Control:

See section M 1c.

**P. Other Supportive Instrument Performance Characteristics Data Not Covered In The “Performance Characteristics” Section above:**

Not Applicable

**Q. Proposed Labeling:**

The labeling is sufficient and it satisfies the requirements of 21 CFR Part 809.10.

**R. Conclusion:**

The submitted information in this premarket notification is complete and supports a substantial equivalence decision.