EXIR

Systems for testing thermal imagers at extreme conditions

Fig. 1. Cross section of a)EXIR-1, b)EXIR-2 , c)EXIR-3 systems for testing thermal imagers at extreme conditions

1 Introduction

Thermal imagers can be considered as the most important type of electro-optical imaging systems used for imaging applications in military, law inforcements and civilian applications. Performance of thermal imagers (understood as ranges of effective surveillance: detection, recognition, identification) can be relatively accurately estimated on basic of measured three important parameters like MRTD, MTF, NETD (or at least MRTD). Measurement of these parameters can be carried out using different test systems offered on the market (including systems offered by Inframet described at section Thermal imagers https://www.inframet.com/thermal_imagers.htm). However, the problem is that typical test systems offer testing thermal imagers only at laboratory conditions. Both imager ambient temperature and target background temperature at laboratory tests are at level about 20C when in real work conditions of surveillance thermal imagers both temperatures can vary from about -40C to about +60C or more. It means that a near perfect imager at laboratory conditions can perform very poorly at extreme ambient/background temperatures. It can also occurs that imager of modest performance at laboratory conditions can keep this performance nearly the same at extreme ambient/background temperatures.

EXIR is a code for a series of systems developed by Inframet to enable accurate testing thermal imagers at simulated real work conditions. Practically it means that EXIR systems enable measurement of important parameters of thermal imagers at both typical laboratory conditions also at extremal conditions.

2 Work conditions

Work conditions of surveillance thermal imagers can be characterized by a set of three parameters:

1) target apparent differential temperature,
2) imager ambient temperature,
3) temperature of background of the target of interest.

All three parameters vary significantly depending on work conditions.

The target apparent differential temperature typically vary in range from several milikelvins to about 10ºC. Both imager ambient temperature and temperature of background of the target vary from about -40ºC to about +60ºC depending on geographical region, period of a year, time, altitude of the imager location, and angular configuration the imager. The latter parameter defines angle of line of sight of the imager relative to horizontal axis (difference between altitude of the imager and altitude of the target of interest). In big simplification it can be said that there are

three main angular configurations of work of thermal imagers:
1) horizontal, 2) slanted down, 3) slanted up.

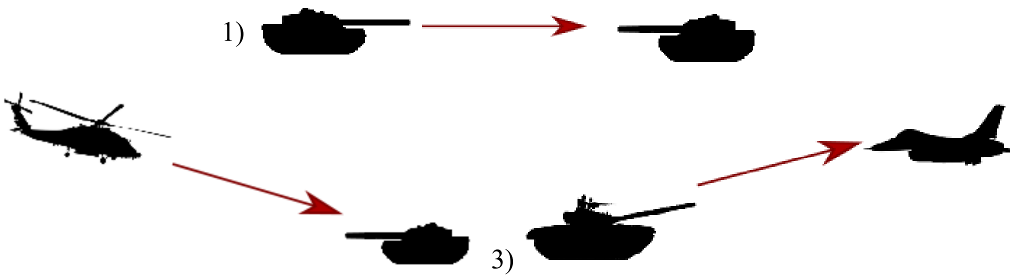

Fig. 2. Angular configurations of work of thermal imagers

There are over a dozen of combinations of two variables: ambient temperature and background temperature when laboratory simulate only one of such combinations (Table 1).

Table 1. Exemplary work scenarios of surveillance thermal imagers

Number	Target differential temperature	Ambient temperature	Background temperature	Description of the scenario
1	0ºC to 5ºC	20ºC	20ºC	Late spring/early autumn, horizontal path (laboratory conditions too)
2	0ºC to 5ºC	-5ºC	-5ºC	Mild winter; both target and imager at ground level, horizontal path
3	0ºC to 5ºC	-40ºC	-40ºC	Harsh winter; horizontal path
4	0ºC to 5ºC	30ºC	30ºC	Summer; horizontal path
5	0ºC to 5ºC	50ºC	50ºC	Hot summer at desert conditions; horizontal path
6	0ºC to 5ºC	-40ºC	-30ºC	Harsh winter; slanted down path
7	0ºC to 5ºC	-25ºC	-5ºC	Mild winter; slanted down path
8	0ºC to 5ºC	15ºC	40ºC	Summer; slanted down path
9	0ºC to 5ºC	5ºC	20ºC	Late spring/early autumn, slanted down path
10	0ºC to 5ºC	-5ºC	-20ºC	Mild winter; slanted up path
11	0ºC to 5ºC	30ºC	+5ºC	Summer; slanted up path
12	0ºC to 5ºC	20ºC	0ºC	Late spring/early autumn, slanted up

3 Influence of work conditions on imager performance

Performance of thermal imagers (range of detection, recognition and identification) depends on target differential temperature. Higher differential temperature means longer distance of effective surveillance. However, even specialist in thermal imaging are often not aware about strong relationship between ranges of effective surveillance and two other parameters (imager ambient temperature, temperature of target background). The latter relationship occurs due to a three main reasons:

1. Performance of optics of thermal imagers depends significantly on imager ambient temperature. Even in case of so called athermal IR objectives there is typically some deterioration of quality of image generated by thermal imagers when working at extreme temperatures (below about 0ºC or over about +40ºC).
2. Spatial noise present in images generated by thermal imagers depends significantly on temperature of the optics/mechanical case. It is a typical situation that thermal imagers working at extreme ambient temperatures deliver images with strong spatial noise (high frequency non uniformities that do not depends on time).
3. Apparent target differential temperature depends on background temperature. It means that the same target

differential temperature will generate different radiometric differential signal perceived by the imager when the same target is located at backgrounds of different absolute temperature.

In such situation the complete evaluation of performance of thermal imagers should be carried out only by measurement of performance parameters at a series of different ambient temperatures and for targets located at several backgrounds of different temperature.

4 Market Situation

Due to reasons listed in previous sections it can be logically expected that it should be a common practice to carry out extensive performance tests of thermal imagers working at myriads of different combinations of ambient temperatures and background temperatures using test systems capable to simulate real work conditions at laboratory building. However, the reality is much different.

There is a series of manufacturers of equipment for testing thermal imagers. However, there is no commercially available test systems capable to simulate real work conditions, or at least to enable regulation of the crucial parameter: variable ambient temperature.

Performance tests of thermal imagers are typically carried out using test systems located at laboratory conditions. These are typically variable target test systems built on idea to use image projectors capable to project images of reference targets seen at background of laboratory ambient temperature.

There are many manufacturers of temperature chambers. Some of such typical chambers are used for testing thermal imagers. However, results of such environmental tests according to MIL-810-STD standard give only information if the imager can survive a certain period of time at extreme ambient temperatures without substantial performance loss after test is finished. The tests do not give information on real performance at extreme ambient temperatures determined by measurement of performance parameters like MRTD, MTF, NETD. No information on performance against targets located at background of extreme temperatures, too.

Finally, sometimes manufacturers of thermal imagers built by themselves test systems in form of a translucent temperature chambers. The imager is inserted to such a chamber and can see a typical laboratory image projector located outside the chamber through a translucent window inserted in a wall of such chamber. Such windows typically generate significant deterioration of image quality of image transmitting by the window. Even bigger drawback of such improvised temperature chambers it fact that they create situation when the tested imager will always see simulated target located on background of laboratory temperature (imager even in ambient temperature -40C will see the target located at background of laboratory temperature). Such situation limits significatnly realism of simulated work condtitions of thermal imagers.

5 Systems for testing thermal imagers at extreme conditions

Inframet has recently developed a series of new systems for testing thermal imagers at simulated real work conditions (including extreme conditions). In details Inframet offers three test systems of different design and different test/simulation capabilities:

1. EXIR-1 systems;
2. EXIR-2 systems,
3. EXIR-3 systems.

EXIR-1 system is a test system built from two blocks: 1. CHI translucent temperature chamber where the tested imager can be inserted; 2. typical laboratory class system DT system testing thermal imagers. Cross section view of EXIR-1 is shown at Fig. 1a, and block diagram at Fig. 3.

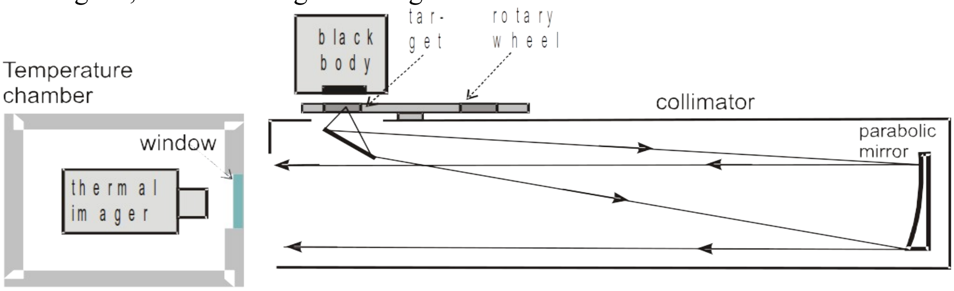

Fig. 3.Block diagram of EXIR-1 test system

It looks apparently easy to built EXIR-1 test system. However, practically designing is difficult due to three main requirements:

1. The window of the chamber must be able to transmit image at MWIR-LWIR spectral band,

2. Deterioration of quality (blurring and angular image displacement) of image transmitted by the window should be negligible for any difference between ambient temperature inside the chamber (image ambient temperature) and external ambient temperature (laboratory temperature),
3. Temperature of background of projected image of a reference target should be similar to ambient temperature of simulated environment (typical situation at real applications).
EXIR-1 test system is the first commercially commercially available test system built using the concept of the translucent temperature chamber that can fulfill all these requirements.
The latter requirement is of particular importance. It means that due to a special design the window in wall of CHI chamber of two special features:

1. the window converts temperature of background of simulated target from typical laboratory temperature to a temperature similar to imager ambient temperature,
2. the window is optimized for work at extreme temperatures and can transmit images with negligible blurring and angular image displacement.

These two features means that there is a big difference between EXIR-1 and low cost similar test systems assembled at some laboratories by combining a commercially available temperature chamber and a commercial IR window. Test results from the latter test systems are totally non accurate because of non proper simulated target background temperature and due to image blurring cased by the window at extreme temperatures.

The second test system, the EXIR-2 system is a set of two blocks: 1) ADT image projector, 2) CHP projector chamber. Cross section view of EXIR-2 is shown at Fig. 1b, and block diagram at Fig. 4.

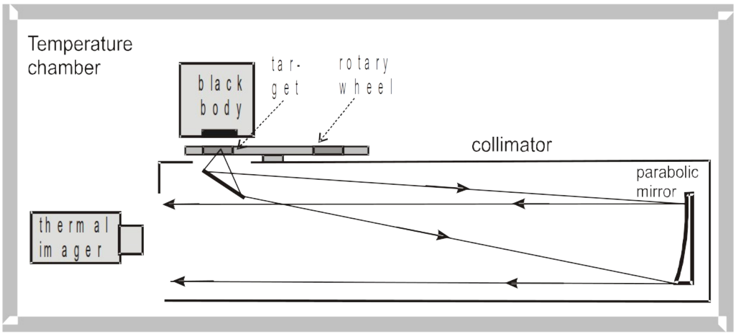

Fig. 4.Block diagram of EXIR-2 test system

ADT system is special version of old mature DT systems for testing thermal imagers (the systems offered by Inframet for last two decades) that is capable to work efficiently in temperature chambers at extreme ambient temperatures. In other words, ADT system can be treated as an athermal image projector capable to project high quality mages of reference targets into direction of tested thermal imager at any ambient temperature inside the chamber.
CHP can be considered as a typical large non translucent chamber offered on the market. CHP must be large enough to accommodate ADT projector and tested imager.
The third test system, the EXIR-3 system is build from a set of three blocks: CHI translucent imager chamber, CHP projector chamber and ADT athermal image projector. Cross section view of EXIR-3 is shown at Fig. 1c, and block diagram at Fig. 5. CHP must have a hole in one of walls to fit to the window of CHI chamber.

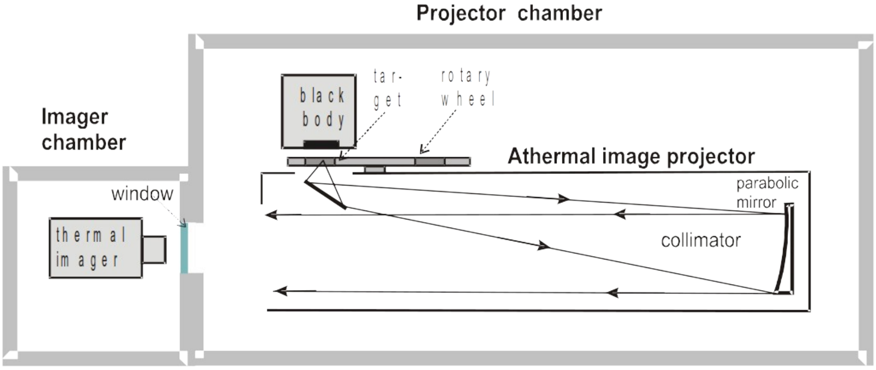

Fig. 5.Block diagram of EXIR-3 test system

The tested imager is inserted to the CHI imager chamber. The ADT athermal image projector is inserted to the CHP projector chamber. The tested imager can see athermal projector via the translucent window in the first chamber and hole in the second chamber. This concept enable independent regulation of both imager ambient temperature and background temperature. It is the first reported test system in the world of such simulation capabilities.

6 Simulation capabilities

The discussed three test systems offer following simulation/test capabilities.

1. EXIR-1 system enables simulation of surveillance scenarios when temperature of background of the target of interest is similar to imager ambient temperature. It is a typical scenario for land applications of thermal imagers.
2. EXIR-2 system offers the same simulation capabilities as EXIR-1 system but simulated background temperature is exactly equal to imager ambient temperature. Maximal aperture of tested imager can be up to about 400mm.
3. EXIR-3 system is the most advanced system offered by Inframet for testing thermal imagers at extreme conditions. It enables simulation of all possible surveillance scenarios met in real applications of thermal imagers. It means that all surveillance scenarios (all combinations of temperature of background of the target of interest and imager ambient temperature) shown Table 1 can be simulated. Maximal aperture of tested imager can be up to about 300mm.

Table 2. Summary of simulation/test capabilities of new test systems

Test system	Target differential temperature	Imager ambient temperature	Background temperature	Applications
EXIR-1	0ºC to 10ºC	-40ºC to +60ºC option: up to +90ºC	regulated in -40ºC to +60ºC but always similar to imager ambient temperature*	Optimized for simulation of horizontal angualar work configuration
EXIR-2	0ºC to 10ºC	-40ºC to +60ºC	regulated in -40ºC to +60ºC but always exactly the same as imager ambient temperature	Optimized for simulation of horizontal angular work configuration
EXIR-3	0ºC to 10ºC	-40ºC to +60ºC	Regulated in -40ºC to +60ºC range. It can be different than imager ambient temperature	Suitable to simulate all types of angular work configurations (horizontal slanged up, slanted down)

* - the following relation is to be fulfulled: $(T_{back}- T_{amb})\approx 0.1\ (T_{lab}- T_{amb})$ where T_{back} is target background temperature, T_{amb} is imager ambient temperature inside the chamber, T_{lab} is laboratory temperature outside the chamber.

The data in Table 2 show that:

- EXIR-3 system enables accurate simulation of all surveillance scenarios listed in Table 1.
- EXIR-2 system enables accurate simulation of typical surveillance scenarios when imager ambient temperature is equal to target background temperature (horizontal angular configurations)
- EXIR-1 system enables limited accuracy simulation of typical surveillance scenarios when imager ambient temperature is equal to target background temperature (horizontal angular configurations). Simulation accuracy is lower than in previous case due to some difference between target background temperature and imager ambient temperature. However, the difference is not high and can be treated as acceptable.
- EXIR-1 and EXIR-2 can be treated as special simplified versions of EXIR-3 system on criterion of capabilities to simulate real work conditions (regulation of imager ambient temperature and target background temperarature).

7 Test capabilities

As presented in previous section there are significant differences in simulation capabilities of EXIR series systems (especially between EXIR-1/EXIR-2 and EXIR-3. However, test capabilities (number of measured parameters) of all three types of EXIR systems are basically the same. All test systems can be used to measure most important parameters of thermal imagers like MRTD, MTF, NETD.

The exact number of measured parameters depends on version of image projector (DT or ADT) used by EXIR systems. This subject will be discussed later.

8 Comparison of types of EXIR system

Here we are present basic comparison between types of EXIR system.

EXIR-1

Advantages:

1. It can be built by upgrading typical laboratory class image projector (additional CHI temperature chamber is needed).
2. Price of building EXIR-1 by upgrading typical laboratory class image projector is significantly lower than price of EXIR-2 or even more lower than price of EXIR-3.
3. Easy access of human operator to the image projector during the tests.

Disadvantages:

1. Lower simulation accuracy of typical surveillance scenarios when imager ambient temperature is equal to target background temperature (horizontal angular configurations) comparing to EXIR-2 and much lower comparing to EXIR-3.
2. Tested imager must be located at significant distance from collimator output due to mechanical constraints (chamber wall and window case). It is not optimal situation.
3. Price of EXIR-1 can be higher than price of EXIR-2 if potential customer does not have laboratory class image projector and EXIR-1 cannot be built using upgrading method.
4. EXIR-1 cannot be used for testing VIS-NIR cameras due to limited spectral band of the window of the CHI chamber even if DT image projector can project image in VIS-NIR band.
5. High prices of systems using large windows (over about 200mm). Economically sound solution for testing images of low/medium aperture (up to about 200mm).

EXIR-2

Advantages:

1. High simulation accuracy of typical surveillance scenarios when imager ambient temperature is equal to target background temperature (horizontal angular configurations).
2. Tested imager can be located at short distance from collimator output. It is optimal situation.
3. Economical solution for testing imagers of aperture up to about 300mm (optional solution for testing imagers/multi-sensor systems of aperture up to 400mm). It means that EXIR-2 enables testing imagers of much higher apeture than EXIR-1.

Disadvantages:

1. No easy access of human operator to the image projector during the tests.
2. It cannot be built by upgrading existing laboratory class image projector (it means higher price than EXIR-1 of similar test capabilties).

EXIR-3

Advantages:

1. High simulation accuracy of all surveillance scenarios (both horizontal and slanted angular configurations).
2. Thermal imagers of aperture up to 200mm (very rare case). Aperture of the window in CHI chamber is the limiting factor – optionally can be used special window of 300mm aperture.

Disadvantages:

1. No easy access of human operator to the image projector during the tests.
2. It cannot be built by upgrading existing laboratory class image projector.
3. Tested imager cannot be located at short distance from collimator output due to mechanical constraints (chamber wall and window case). It is not optimal situation.
4. Significantly higher price comparing to EXIR-2 (and even more comparing to EXIR-1 built by upgrading old image projector)

9 Versions

All main types of EXIR system (EXIR-1, EXIR-2, EXIR-3) are modular systems that can be built using slightly different modules. Therefore each type of EXIR system can be delivered in form of many versions of different design and different test capabilities (number of measured parameters).

9.1 EXIR-1

EXIR-1 system is built from two blocks: CHI image chamber and DT test system (laboratory class image projector). However, it is assumed that EXIR-1 is built by modernization of DT system. It means that the customer has already posses DT system and now wants to upgrade it to get abilities to tests thermal imagers at simulated

extreme conditions. In such situation only purchase of CHI imager is needed. However, the latter block must be chosen properly.
There are three main rules for proper choice of CHI imager chamber for EXIR-1:

1. Aperture of window in wall of the CHI imager should be appoximately the same as aperture of CDT collimator of the DT image projector,
2. Spectral transmission band of the window must overlap spectral sensitivity band of the tested imager,
3. Internal dimensions of CHI chamber must be large enough to accommodate for tested imager.

Concept of EXIR-1 is based on assumtion that the system is to be optimized for testing imager of optical apertures from about 50mm to about 200mm. In detail, apertures of LWIR imagers from about 50mm to 150mm and apertures of MWIR imagers from about 50mm to about 200mm. Next, Inframet prefers to offer large chambers to ensure that there is enough space for tested imager.
Therefore Inframet offers three CHI chambers (Table 3).

Table 3. Basic parameters of CHI chambers

Chamber code	Internal dimensions width × depth × height [cm]	Window active aperture	Acceptable spectral bands of tested imager
CHI-S-100-312	20×50×20	100 mm	3-5 µm or 8-12 µm
CHI-M-150-312	50×75×60	150 mm	3-5 µm or 8-12 µm
CHI-M-200-35	50×75×60	200mm	only 3-5 µm

All CHI chambers can be delivered optimized for slightly different temperature range: temperature range: A)-40ºC to +60ºC, B)-20ºC to +80ºC, C)-40ºC to +80ºC (please add letter A, B or C to the code).
Rules for choosing proper version of EXWIR-1:

1. CHI-S-100-312: Testing LWIR imagers or MWIR imagers of aperture from about 30mm to 100mm
2. CHI-M-150-312: Testing LWIR imagers or MWIR imagers of aperture from about 40mm to 150mm
3. CHI-M-200-35: Testing MWIR imagers of aperture from about 30mm to 200mm

Example code:
EXIR-1=CHI-M-150-312 + DT150 BBBAA-AAAAA
It means EXIR-1 system built using DT150 BBBAA-AAAAA test system (customer already has such system) and CHI-M-150-312 (as defined in Table 3)

9.2 EXIR-2

The EXIR-2 system is a set of two blocks: 1) ADT image projector, 2) CHP projector chamber. Therefore in order to decribe EXIR-2 it is needed to describe precisely both blocks.
ADT is offered in a series of versions decribe depending on four criteria: collimator aperture, test capabilities, boresight capabilites, collimator focusing.
On criterion of collimator aperture ADT is divided into following versions

Table 4. Division of ADT series systems based on the collimator aperture

System aperture code	Collimator output aperture [mm]	Collimator focal lenth [mm]	Collimator code
ADT 110	110	1000	CDT1100
ADT 120	120	1000	CDT12100
ADT 150	150	1500 or 1200	CDT15120 or CDT15150
ADT 200	200	2000 or 1600	CDT20160 or CDT20200
ADT250	250	2000	CDT25200
ADT300	300	2000 or 3000	CDT30200 or CDT30300t

ADT projector is further divided using three letter code description presented in table below.

Table 5. Definition of versions of ADT system depending on system capabilities

Code letter	Test capabilities	Boresight capabilties	Collimator focusing
A	Resolution	No	Fixed focus. Only infinity

B	Additionallly MRTD	Zoom/focus through	Variable focus
C	Additionally MTF, NETD, FOV	Additionally boresight to reference mechanica plane	
D	Additionally magnification (for direct view imagers)	Additionally boresight to reference mechanica axis	

Description of code:
Test capabilities are described by list of measured parameters. Measurement of these parameters is important for any type of ther imagers: surveillance cameras or sights, imagers that generate only electronic image or direct view imagers (generate both optical image and electronic image).
1A. System enables only measurement of resolution using IR USAF 1951 target and non- calibrated blackbody.
1B. System enables measurement of MRTD using a set of 4-bar targets, MRW-8 rotary wheel, TCB-2D blackbody and special system to eliminate variable offset of this blackbody (at least five times reduction comparing to typical laboratory class systems). The latter feature is critical to enable accurate measurement of MRTD.
1C. Measurement of objective parameters like MTF, NETD, FOV is possible too.
1D. Measurement of magnification of direct view imagers (imagers having internal display) is possible, too.
Boresight capabilities decribe abilities to measure angular alignment errors. These are angles between different optical and mechanical axis. They are important only for thermal sights/targeting systems.
2A. No boresight capabilities.
2B. Measurement of angle between point indicated by imager line of sight when zooming or focusing.
2C. Measurement of angle between between line of sight (or center of FOV) and reference mechanical plane (typically front wall of thermal imager.
2D. Measurement of angle between between line of sight (or center of FOV) and reference mechancal axis (typically mechanical axis of mount the image is attached.
Attention: Boresight capabilities 2C and 2D are optional that can be confirmed by Inframet only after delivery of detail information on tested imager (typically external mechanical drawings are needed)
3A. Test targets is located at collimator focal plane to simulate target at optical infinity. No refocusing possible.
3B. Position of the test targets relative to collimator focal plane can be regulated in range at least ±5mm. This option is useful in case of testing imagers built using partially athermal IR objectives. Such objectives can generate high quality image at any ambient temperature in the working range but need manual refocusing when ambient temperature is changes. When tested imager is inside the chamber then manual refocusing is not possible and refocusing of the collimator must be used.

The second main block of EXIR-2, the CHP chamber is offered in three versions

Table 6. Definition of versions of CHP chamber

Chamber code	Internal dimensions width × depth × height [cm]	Optimized for systems
CHP-S	50×160×80	ADT110, ADT120
CHP-M	55×280×100	ADT150, ADT200
CHP-L	60×400×120	ADT250, ADT300

Example code: of EXIR-2 system:
EXIR-2=ADT150 BBB +CHP-M
It means EXIR-2 built from ADT150 BBB (ADT image projector built using a collimator of aperture 150mm and capable to measure MRTD, resolution; do zoom/focus through boresight and be capble to do collimator refocusing) and CHP-M (as defined in Table 6).

9.3 EXIR-3

EXIR-3 system is build from a set of three blocks: CHI translucent imager chamber, CHP projector chamber and ADT athermal image projector. CHI translucent imager chambers used in EXIR-3 are the same as used in EXIR-1. CHP projector chambers used in EXIR-3 are almost the same as used in EXIR-2. The only difference is that in case of EXIR-3 additional hole in a wall of CHP chamber is needed. ADT athermal image projectors used in EXIR-3 are the same as used in EXIR-2. Therefore the same tables that decribe CHI, CHP and ADT blocks presented in previous subsections can be now used to describe EXIR-3.

CHI, CHP and ADT are independent blocks but they must cooperate. Therefore they must be properly chosen using several rules:

1. Window aperture of CHI should be approximately equal collimator aperture of ADT image projector.
2. Internal dimensions of CHI chamber must be high enough to accommodate for imager to be inserted.
3. Internal dimensions of CHP must be high enough to accommodate for ADT projector to be inserted.

Example EXIR-3 system:
EXIR-3=CHI-M-150-312 + ADT150 BBB + CHP-M.
CHI-M-150-312 as defined in Table 3. ADT150 BBB as defined in Table 4 and Table 5. CHP as defined in Table 6.

10 Applications of new test systems

The new test systems enable measurement of a long series of parameters of thermal imagers at variable imager ambient temperature and target background temperature. The most important are such parameters as: MRTD, MTF, NETD, FPN. It should be noted also that measurement of the first parameter enables indirect determination of ranges of effective surveillance according rules presented in a NATO standard.

Inframet has carried out tests of a series of surveillance thermal imagers at simulated real work conditions using the systems presented in previous sections (mostly using EXIR-3 system). The tests have been conducted by measurement of earlier listed parameters for different combinations of imager ambient temperature and target background temperature.

The main conclusion from these tests is that performance parameters of thermal imagers offered on market vary a lot depending on ambient temperature and background temperature. A near perfect imager at laboratory condition can perform very poorly at extreme ambient/background temperatures. It can also occur that imager of modest performance at laboratory conditions can keep this performance nearly the same at extreme ambient/background temperatures. It can be also surprising that linear relationship between price and performance is not always valid.

Sample of detail conclusions are listed below:

1. There have been met cases of thermal imagers that could not survive the tests (stopped generating output image when working at extreme ambient temperatures),
2. There have been met a single case of a thermal imager that generated saturated image when observing target located at background of high temperature (over 50 ºC),
3. The ranges of effective surveillance (calculated according to rules of STANAG 4347 standard) can drop over 2 times in case of some imagers when imager works at extreme conditions (ambient temperature below -10ºC or over +50ºC),
4. It has been observed for of all tested imagers a general trend that NETD increases at low background temperature (increase as high as 40% -30ºC comparing to lab temperature),
5. FPN of tested imagers can deteriorate as high as 5 times (especially for non cooled imagers) when imager working at extreme conditions comparing to laboratory conditions,
6. MTF of some thermal imagers is very sensitive to imager ambient temperature. There have been met a case when change of ambient temperature from +20ºC to -30ºC has generated change of MTF from level of 0.6 at 4 lp/mrad (ability to produce sharp image) to below 0.05 (strongly blurred useless image).

The data in form of parameters of thermal imagers measured at different work conditions can be of high value for both users and designers of thermal imagers. Such data give answers to a series of questions about performance of thermal imagers working at real work conditions.

Users of thermal imagers:

1. What is deterioration of imager performance (range of effective surveillance against target of interest) when imager works at extreme conditions (extreme imager ambient temperature, extreme background temperature) comparing to the ranges calculated on bases of parameters measured at laboratory conditions?
2. Is imager performance at simulated real work conditions suitable for planned applications?

Designers of thermal imagers:

1. What is deterioration of performance of imager optics when imager works at extreme ambient conditions? MTF can be used as a measure of optics performance.
2. Does the image processing algorithm to correct spatial noise works effectively at any imager ambient temperature? FPN can be considered as a measure of the high frequency spatial noise.
3. How big is apparent increase of temporal noise when looking on targets located at backgrounds of very low temperature? NETD can be considered as a measure of temporal noise.
4. Are the gain levels of electronic channels set properly? Can the imager deliver sharp images of targets located on background of temperature variable in range of interest or there are cases when the image is

saturated?

11 Summary

Inframet has developed EXIR series test systems that enable expanded testing of surveillance thermal imagers at accurately simulated real work conditions. Such systems can simulate work of these imagers not only at typical laboratory conditions but also at extreme conditions.

Applications of these new tests systems in process of evaluation of surveillance thermal imagers can bring revolution in thermal imaging metrology. The new test systems enable much more accurate evaluation of performance of thermal imagers at real work conditions comparing to typical test systems capable only to simulate laboratory conditions. The new test systems can also show new ways of technical modifications to improve performance at ral work conditions. Therefore the EXIR test systems can become in near future a very valuable tool for both users and manufacturers of thermal imagers.

Version 1.4

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