- "What's New in V3R7?" on page xl
- "What's New in V3R6/V3R2?" on page xliv

You can use this section to link to and learn about new RPG IV functions.

Note: The information for this product is up-to-date with the V6R1 release of RPG IV. If you are using a previous release of the compiler, you will need to determine what functions are supported on your system. For example, if you are using a V5R1 system, the functions new to the V6R1 release will not be supported.

What's New in this Release

This section describes the enhancements made to ILE RPG in V6R1.

THREAD(*CONCURRENT)

When THREAD(*CONCURRENT) is specified on the Control specification of a module, it provides ability to run concurrently in multiple threads:

- Multiple threads can run in the module at the same time.
- By default, static variables will be defined so that each thread will have its own copy of the static variable.
- Individual variables can be defined to be shared by all threads using STATIC(*ALLTHREAD).
- Individual procedures can be serialized so that only one thread can run them at one time, by specifying SERIALIZE on the Procedure-Begin specification.

Ability to define a main procedure which does not use the RPG cycle

Using the MAIN keyword on the Control specification, a subprocedure can be identified as the program entry procedure. This allows an RPG application to be developed where none of the modules uses the RPG cycle.

Files defined in subprocedures

Files can be defined locally in subprocedures. I/O to local files can only be done with data structures; I and O specifications are not allowed in subprocedures, and the compiler does not generate I and O specifications for externally described files. By default, the storage associated with local files is automatic; the file is closed when the subprocedure returns. The STATIC keyword can be used to indicate that the storage associated with the file is static, so that all invocations of the subprocedure will use the same file, and if the file is open when the subprocedure returns, it will remain open for the next call to the subprocedure.

Qualified record formats

When a file is defined with the QUALIFIED keyword, the record formats must be qualified by the file name, MYFILE.MYFMT. Qualified files do not have I and O specifications generated by the compiler; I/O can only be done through data structures.

Files defined like other files

Using the LIKEFILE keyword, a file can be defined to use the same settings as another File specification, which is important when passing a file as a parameter. If

the file is externally-described, the QUALIFIED keyword is implied. I/O to the new file can only be done through data structures.

Files passed as parameters

A prototyped parameter can be defined as a File parameter using the LIKEFILE keyword. Any file related through the same LIKEFILE definition may be passed as a parameter to the procedure. Within the called procedure or program, all supported operations can be done on the file; I/O can only be done through data structures.

EXTDESC keyword and EXTFILE(*EXTDESC)

The EXTDESC keyword identifies the file to be used by the compiler at compile time to obtain the external decription of the file; the filename is specified as a literal in one of the forms 'LIBNAME/FILENAME' or 'FILENAME'. This removes the need to provide a compile-time override for the file.

The EXTFILE keyword is enhanced to allow the special value *EXTDESC, indicating that the file specified by EXTDESC is also to be used at runtime.

EXTNAME to specify the library for the externally-described data structure

The EXTNAME keyword is enhanced to allow a literal to specify the library for the external file. EXTNAME('LIBNAME/FILENAME') or EXTNAME('FILENAME') are supported. This removes the need to provide a compile-time override for the file.

EXFMT allows a result data structure

The EXFMT operation is enhanced to allow a data structure to be specified in the result field. The data structure must be defined with usage type *ALL, either as an externally-described data structure for the record format (EXTNAME(file:fmt:*ALL), or using LIKEREC of the record format (LIKEREC(fmt:*ALL).

Larger limits for data structures, and character, UCS-2 and graphic variables

- Data structures can have a size up to 16,773,104.
- Character definitions can have a length up to 16,773,104. (The limit is 4 less for variable length character definitions.)
- Character definitions can have a length up to 16,773,104. (The limit is 4 less for variable length character definitions.)
- UCS-2 definitions can have a length up to 8,386,552 UCS-2 characters. (The limit is 2 less for variable length UCS-2 definitions.)
- Graphic definitions can have a length up to 8,386,552 DBCS characters. (The limit is 2 less for variable length graphic definitions.)
- The VARYING keyword allows a parameter of either 2 or 4 indicating the number of bytes used to hold the length prefix.

%ADDR(varying : *DATA)

The %ADDR built-in function is enhanced to allow *DATA as the second parameter to obtain the address of the data part of a variable length field.

Larger limit for DIM and OCCURS

An array or multiple-occurrence data structure can have up to 16,773,104 elements, provided that the total size is not greater than 16,773,104.

Larger limits for character, UCS-2 and DBCS literals

- Character literals can now have a length up to 16380 characters.
- UCS-2 literals can now have a length up to 8190 UCS-2 characters.
- Graphic literals can now have a length up to 16379 DBCS characters.

TEMPLATE keyword for files and definitions

The TEMPLATE keyword can be coded for file and variable definitions to indicate that the name will only be used with the LIKEFILE, LIKE, or LIKEDS keyword to define other files or variables. Template definitions are useful when defining types for prototyped calls, since the compiler only uses them at compile time to help define other files and variables, and does not generate any code related to them.

Template data structures can have the INZ keyword coded for the data structure and its subfields, which will ease the use of INZ(*LIKEDS).

Relaxation of some UCS-2 rules

The compiler will perform some implicit conversion between character, UCS-2 and graphic values, making it unnecessary to code %CHAR, %UCS2 or %GRAPH in many cases. This enhancement is also available through PTFs for V5R3 and V5R4. Implicit conversion is now supported for

- Assignment using EVAL and EVALR.
- Comparison operations in expressions.
- Comparison using fixed form operations IFxx, DOUxx, DOWxx, WHxx, CASxx, CABxx, COMP.
- Note that implicit conversion was already supported for the conversion operations MOVE and MOVEL.

UCS-2 variables can now be initialized with character or graphic literals without using the %UCS2 built-in function.

Eliminate unused variables from the compiled object

New values *UNREF and *NOUNREF are added to the OPTION keyword for the CRTBNDRPG and CRTRPGMOD commands, and for the OPTION keyword on the Control specification. The default is *UNREF. *NOUNREF indicates that unreferenced variables should not be generated into the RPG module. This can reduce program size, and if imported variables are not referenced, it can reduce the time taken to bind a module to a program or service program.

PCML can now be stored in the module

Program Call Markup Language (PCML) can now be stored in the module as well as in a stream file. By using combinations of the PGMINFO command parameter and/or the new PGMINFO keyword for the Control specification, the RPG programmer can choose where the PCML information should go. If the PCML information is placed in the module, it can later be retrieved using the QBNRPII API. This enhancement is also available through PTFs for V5R4, but only through the Control specification keyword.

What's New

Table 1. Changed Language Elements Since V5R4

Language Unit	Element	Description
Control specification keywords	OPTION(*UNREF | *NOUNREF)	Specifies that unused variables should not be generated into the module.
	THREAD(*CONCURRENT)	New parameter *CONCURRENT allows running concurrently in multiple threads.
File specification keywords	EXTFILE(*EXTDESC)	Specifies that the value of the EXTDESC keyword is also to be used for the EXTFILE keyword.
Built-in functions	%ADDR(varying-field : *DATA)	Can now be used to obtain the address of the data portion of a varying-length variable.
Definition specification keywords	DIM(16773104)	An array can have up to 16773104 elements.
	EXTNAME('LIB/FILE')	Allows a literal for the file name. The literal can include the library for the file.
	OCCURS(16773104)	A multiple-occurrence data structure can have up to 16773104 elements.
	VARYING{(2|4)}	Can now take a parameter indicating the number of bytes for the length prefix.
Definition specifications	Length entry	Can be up to 9999999 for Data Structures, and definitions of type A, C or G. (To define a longer item, the LEN keyword must be used.)
Input specifications	Length entry	Can be up to 99999 for alphanumeric fields, and up to 99998 for UCS-2 and Graphic fields.
Calculation specifications	Length entry	Can be up to 99999 for alphanumeric fields.
Operation codes	EXFMT format { result-ds }	Can have a data structure in the result entry.

Table 2. New Language Elements Since V5R4

Language Unit	Element	Description
Control specification keywords	MAIN(subprocedure-name)	Specifies that unused variables should not be generated into the module.
	PGMINFO(*NO | *PCML { : *MODULE })	Indicates whether Program Information is to be placed directly in the module.

Table 2. New Language Elements Since V5R4 (continued)

Language Unit	Element	Description
File specification keywords	STATIC	Indicates that a local file retains its program state across calls to a subprocedure.
	QUALIFIED	Indicates that the record format names of the file are qualified by the file name, FILE.FMT.
	LIKEFILE(filename)	Indicates that the file is defined the same as another file.
	TEMPLATE	Indicates that the file is only to be used for later LIKEFILE definitions.
	EXTDESC(constant-filename)	Specifies the external file used at compile time for the external definitions.
Definition specification keywords	STATIC(*ALLTHREAD)	Indicates that the same instance of the static variable is used by all threads running in the module.
	LIKEFILE(filename)	Indicates that the parameter is a file.
	TEMPLATE	Indicates that the definition is only to be used for LIKE or LIKEDS definitions.
	LEN(length)	Specifies the length of a data structure, or a definition of type A, C or G.
Procedure specification keywords	SERIALIZE	Indicates that the procedure can be run by only one thread at a time.

Changes to this Guide Since V5R4

This V6R1 guide, *WebSphere Development Studio: ILE RPG Programmer's Guide*, SC09-2507-07, differs in many places from the V5R4 guide, SC09-2507-06. Most of the changes are related to the enhancements that have been made since previous releases; others reflect minor technical corrections.

Note: Changes for V6R1 are marked with a revision bar: (|).

What's New in V5R4?

The following list describes the enhancements made to ILE RPG in V5R4:

New operation code EVAL-CORR

```
EVAL-CORR{(EH)} ds1 = ds2
```

New operation code EVAL-CORR assigns data and null-indicators from the subfields of the source data structure to the subfields of the target data

structure. The subfields that are assigned are the subfields that have the same name and compatible data type in both data structures.

For example, if data structure DS1 has character subfields A, B, and C, and data structure DS2 has character subfields B, C, and D, statement EVAL-CORR DS1 = DS2; will assign data from subfields DS2.B and DS2.C to DS1.B and DS1.C. Null-capable subfields in the target data structure that are affected by the EVAL-CORR operation will also have their null-indicators assigned from the null-indicators of the source data structure's subfields, or set to *OFF, if the source subfield is not null-capable.

```
//  DS1 subfields        DS2 subfields
//    s1  character        s1 packed
//    s2  character        s2 character
//    s3  numeric
//    s4  date             s4 date
//                         s5 character
EVAL-CORR  ds1 = ds2;
// This EVAL-CORR operation is equivalent to the following EVAL operations
//    EVAL ds1.s2 = ds2.s2
//    EVAL ds1.s4 = ds2.s4
// Other subfields either appear in only one data structure (S3 and S5)
// or have incompatible types (S1).
```

EVAL-CORR makes it easier to use result data structures for I/O operations to externally-described files and record formats, allowing the automatic transfer of data between the data structures of different record formats, when the record formats have differences in layout or minor differences in the types of the subfields.

New prototyped parameter option OPTIONS(*NULLIND)

When OPTIONS(*NULLIND) is specified for a parameter, the null-byte map is passed with the parameter, giving the called procedure direct access to the null-byte map of the caller's parameter.

New builtin function %XML

%XML (*xmldocument* { : *options* })

The %XML builtin function describes an XML document and specifies options to control how the document should be parsed. The **xmldocument** parameter can be a character or UCS-2 expression, and the value may be an XML document or the name of an IFS file containing an XML document. If the value of the **xmldocument** parameter has the name of a file, the "doc=file" option must be specified.

New builtin function %HANDLER

%HANDLER (*handlingProcedure* : *communicationArea*)

%HANDLER is used to identify a procedure to handle an event or a series of events. %HANDLER does not return a value, and it can only be specified as the first operand of XML-SAX and XML-INTO.

The first operand, *handlingProcedure*, specifies the prototype of the handling procedure. The return value and parameters specified by the prototype must match the parameters required for the handling procedure; the requirements are determined by the operation that %HANDLER is specified for.

The second operand, *communicationArea*, specifies a variable to be passed as a parameter on every call to the handling procedure. The operand must be an exact match for the first prototyped parameter of the handling procedure,

according to the same rules that are used for checking prototyped parameters passed by reference. The communication-area parameter can be any type, including arrays and data structures.

New operation code XML-SAX

```
XML-SAX{ (e) } %HANDLER(eventHandler : commArea ) %XML(xmldocument { : saxOptions } );
```

XML-SAX initiates a SAX parse for the XML document specified by the %XML builtin function. The XML-SAX operation begins by calling an XML parser which begins to parse the document. When the parser discovers an event such as finding the start of an element, finding an attribute name, finding the end of an element etc., the parser calls the *eventHandler* with parameters describing the event. The *commArea* operand is a variable that is passed as a parameter to the *eventHandler* providing a way for the XML-SAX operation code to communicate with the handling procedure. When the *eventHandler* returns, the parser continues to parse until it finds the next event and calls the *eventHandler* again.

New operation code XML-INTO

```
XML-INTO{ (EH) } variable   %XML(xmlDoc { : options });
XML-INTO{ (EH) } %HANDLER(handler : commArea ) %XML(xmlDoc { : options });
```

XML-INTO reads the data from an XML document in one of two ways:
- directly into a variable
- gradually into an array parameter that it passes to the procedure specified by %HANDLER.

Various options may be specified to control the operation.

The first operand specifies the target of the parsed data. It can contain a variable name or the % HANDLER built-in function.

The second operand contains the %XML builtin function specifying the source of the XML document and any options to control how the document is parsed. It can contain XML data or it can contain the location of the XML data. The doc option is used to indicate what this operand specifies.

```
// Data structure "copyInfo" has two subfields, "from"
// and "to".  Each of these subfields has two subfields
// "name" and "lib".
// File cpyA.xml contains the following XML document
// <copyinfo>
//    <from><name>MASTFILE</name><lib>CUSTLIB</lib></from>
//    <to><name>MYFILE</name><lib>*LIBL</lib>
// <copyinfo>
xml-into copyInfo %XML('cpyA.xml' : 'doc=file');
// After the XML-INTO operation, the following
// copyInfo.from .name = 'MASTFILE ' .lib = 'CUSTLIB  '
// copyInfo.to   .name = 'MYFILE   ' .lib = '*LIBL    '
```

Use the PREFIX keyword to remove characters from the beginning of field names

```
PREFIX('' : number_of_characters)
```

When an empty character literal (two single quotes specified with no intervening characters) is specified as the first parameter of the PREFIX keyword for File and Definition specifications, the specified number of characters is removed from the field names. For example if a file has fields XRNAME, XRIDNUM, and XRAMOUNT, specifying PREFIX('':2)on the File specification will cause the internal field names to be NAME, IDNUM, and AMOUNT.

What's New

If you have two files whose subfields have the same names other than a file-specific prefix, you can use this feature to remove the prefix from the names of the subfields of externally-described data structures defined from those files. This would enable you to use EVAL-CORR to assign the same-named subfields from one data structure to the other. For example, if file FILE1 has a field F1NAME and file FILE2 has a field F2NAME, and PREFIX(''`:2`) is specified for externally-described data structures DS1 for FILE1 and DS2 for FILE2, then the subfields F1NAME and F2NAME will both become NAME. An EVAL-CORR operation between data structures DS1 and DS2 will assign the NAME subfield.

New values for the DEBUG keyword

```
DEBUG { ( *INPUT  *DUMP  *XMLSAX *NO *YES ) }
```

The DEBUG keyword determines what debugging aids are generated into the module. *NO and *YES are existing values. *INPUT, *DUMP and *XMLSAX provide more granularity than *YES.

*INPUT
  Fields that appear only on input specifications are read into the program fields during input operations.

*DUMP
  DUMP operations without the (A) extender are performed.

*XMLSAX
  An array of SAX event names is generated into the module to be used while debugging a SAX event handler.

*NO
  Indicates that no debugging aids are to be generated into the module. Specifying DEBUG(*NO) is the same as omitting the DEBUG keyword.

*YES
  This value is kept for compatibility purposes. Specifying DEBUG(*YES) is the same as specifying DEBUG without parameters, or DEBUG(*INPUT : *DUMP).

Syntax-checking for free-form calculations

In SEU, free-form statements are now checked for correct syntax.

Improved debugging support for null-capable subfields of a qualified data structure

When debugging qualified data structures with null-capable subfields, the null-indicators are now organized as a similar data structure with an indicator subfield for every null-capable subfield. The name of the data structure is _QRNU_NULL_*data_structure_name*, for example _QRNU_NULL_MYDS. If a subfield of the data structure is itself a data structure with null-capable subfields, the null- indicator data structure will similarly have a data structure subfield with indicator subfields. For example, if data structure DS1 has null-capable subfields DS1.FLD1, DS1.FLD2, and DS1.SUB.FLD3, you can display all the null-indicators in the entire data structure using the debug instruction.

```
===> EVAL _QRNU_NULL_DS
> EVAL _QRNU_NULL_DS1
  _QRNU_NULL_DS1.FLD1 = '1'
  _QRNU_NULL_DS1.FLD2 = '0'
  _QRNU_NULL_DS1.SUB.FLD3 = '1'
===> EVAL _QRNU_NULL_DS.FLD2
  _QRNU_NULL_DS1.FLD2 = '0'
```

```
===> EVAL _QRNU_NULL_DS.FLD2 = '1'
===> EVAL DSARR(1).FLD2
  DSARR(1).FLD2 = 'abcde'

===> EVAL _QRNU_NULL_DSARR(1).FLD2

  _QRNU_NULL_DSARR(1).FLD2 = '0'
```

Change to end-of-file behaviour with shared files

If a module performs a keyed sequential input operation to a shared file and it results in an EOF condition, and a different module sets the file cursor using a positioning operation such as SETLL, a subsequent sequential input operation by the first module may be successfully done. Before this change, the first RPG module ignored the fact that the other module had repositioned the shared file.

This change in behaviour is available with PTFs for releases V5R2M0 (SI13932) and V5R3M0 (SI14185).

Table 3. Changed Language Elements Since V5R3

Language Unit	Element	Description
Control specification keywords	DEBUG(*INPUT|*DUMP *XMLSAX|*NO|*YES)	New parameters *INPUT, *DUMP and *XMLSAX give more options for debugging aids.
File specification keywords	PREFIX('':2)	An empty literal may be specified as the first parameter of the PREFIX keyword, allowing characters to be removed from the beginning of names.
Definition specification keywords	OPTIONS(*NULLIND)	Indicates that the null indicator is passed with the parameter.
	PREFIX('':2)	An empty literal may be specified as the first parameter of the PREFIX keyword, allowing characters to be removed from the beginning of names.

Table 4. New Language Elements Since V5R3

Language Unit	Element	Description
Built-in functions	%HANDLER(prototype: parameter)	Specifies a handling procedure for an event.
	%XML(document{:options})	Specifies an XML document and options to control the way it is parsed.

Table 4. New Language Elements Since V5R3 (continued)

Language Unit	Element	Description
Operation codes	EVAL-CORR	Assigns data and null-indicators from the subfields of the source data structure to the subfields of the target data structure.
	XML-INTO	Reads the data from an XML document directly into a program variable.
	XML-SAX	Initiates a SAX parse of an XML document.

What's New in V5R3?

The following list describes the enhancements made to ILE RPG in V5R3:

- **New builtin function %SUBARR:**

  New builtin function %SUBARR allows assignment to a sub-array or returning a sub-array as a value.

  Along with the existing %LOOKUP builtin function, this enhancements enables the implementation of dynamically sized arrays with a varying number of elements.

  %SUBARR(array : start) specifies array elements array(start) to the end of the array

  %SUBARR(array : start : num) specifies array elements array(start) to array(start + num - 1)

  Example:

  ```
  // Copy part of an array to another array:
  resultArr = %subarr(array1:start:num);
  // Copy part of an array to part of another array:
  %subarr(Array1:x:y) = %subarr(Array2:m:n);
  // Sort part of an array
  sorta %subarr(Array3:x:y);

  // Sum part of an array
  sum = %xfoot(%subarr(Array4:x:y));
  ```

- **The SORTA operation code is enhanced to allow sorting of partial arrays.**

  When %SUBARR is specified in factor 2, the sort only affects the partial array indicated by the %SUBARR builtin function.

- **Direct conversion of date/time/timestamp to numeric, using %DEC:**

  %DEC is enhanced to allow the first parameter to be a date, time or timestamp, and the optional second parameter to specify the format of the resulting numeric value.

  Example:

  ```
  D numDdMmYy       s             6p 0
  D date            s               d    datfmt(*jul)
    date = D'2003-08-21';
    numDdMmYy = %dec(date : *dmy);
    // now numDdMmYy = 210803
  ```

- **Control specification CCSID(*CHAR : *JOBRUN) for correct conversion of character data at runtime:**

  The Control specification CCSID keyword is enhanced to allow a first parameter of *CHAR. When the first parameter is *CHAR, the second parameter must be

*JOBRUN. CCSID(*CHAR : *JOBRUN) controls the way character data is converted to UCS-2 at runtime. When CCSID(*CHAR:*JOBRUN) is specified, character data will be assumed to be in the job CCSID; when CCSID(*CHAR : *JOBRUN) is not specified, character data will be assumed to be in the mixed-byte CCSID related to the job CCSID.

- **Second parameter for %TRIM, %TRIMR and %TRIML indicating what characters to trim:**

  %TRIM is enhanced to allow an optional second parameter giving the list of characters to be trimmed.

  Example:

  ```
  trimchars = '*-.';
  data = '***a-b-c-.'
  result = %trim(data : trimchars);
  // now result = 'a-b-c'.  All * - and . were trimmed from the ends of the data
  ```

- **New prototype option OPTIONS(*TRIM) to pass a trimmed parameter:**

  When OPTIONS(*TRIM) is specified on a prototyped parameter, the data that is passed be trimmed of leading and trailing blanks. OPTIONS(*TRIM) is valid for character, UCS-2 and graphic parameters defined with CONST or VALUE. It is also valid for pointer parameters defined with OPTIONS(*STRING). With OPTIONS(*STRING : *TRIM), the passed data will be trimmed even if a pointer is passed on the call.

  Example:

  ```
  D proc            pr
  D   parm1                       5a      const options(*trim)
  D   parm2                       5a      const options(*trim : *rightadj)
  D   parm3                       5a      const varying options(*trim)
  D   parm4                        *      value options(*string : *trim)
  D   parm5                        *      value options(*string : *trim)
  D ptr             s              *
  D data            s             10a
  D fld1            s              5a

   /free
     data = ' rst ' + x'00';
     ptr = %addr(data);

     proc (' xyz ' : ' @#$ ' : ' 123 ' : ' abc ' : ptr);
     // the called procedure receives the following parameters
     //    parm1 = 'xyz  '
     //    parm2 = '  @#$'
     //    parm3 = '123'
     //    parm4 = a pointer to 'abc.' (where . is x'00')
     //    parm5 = a pointer to 'rst.' (where . is x'00')
  ```

- **Support for 63 digit packed and zoned decimal values**

  Packed and zoned data can be defined with up to 63 digits and 63 decimal positions. The previous limit was 31 digits.

- **Relaxation of the rules for using a result data structure for I/O to externally-described files and record formats**

  - The result data structure for I/O to a record format may be an externally-described data structure.
  - A data structure may be specified in the result field for I/O to an externally-described file name for operation codes CHAIN, READ, READE, READP and READPE.

  Examples:

  1. The following program writes to a record format using from an externally-described data structure.

```
Foutfile    o    e            k disk
D outrecDs       e ds                      extname(outfile) prefix(O_)
/free
  O_FLD1 = 'ABCDE';
  O_FLD2 = 7;
  write outrec outrecDs;
  *inlr = *on;
/end-free
```

2. The following program reads from a multi-format logical file into data
   structure INPUT which contains two overlapping subfields holding the fields
   of the respective record formats.

```
Flog        if   e            k disk     infds(infds)
D infds          ds
D   recname              261    270
D input          ds                      qualified
D   rec1                                 likerec(rec1) overlay(input)
D   rec2                                 likerec(rec2) overlay(input)
 /free
  read log input;
  dow not %eof(log);
   dsply recname;
   if recname = 'REC1';
    // handle rec1
   elseif recname = 'REC2';
    // handle rec2
   endif;
   read log input;
  enddo;
  *inlr = *on;
 /end-free
```

- If a program/module performs a keyed sequential input operation to a shared
  file and it results in an EOF condition, a subsequent sequential input operation
  by the same program/module may be attempted. An input request is sent data
  base and if a record is available for input, the data is moved into the
  program/module and the EOF condition is set off.

- **Support for new environment variables for use with RPG programs calling
  Java methods**
  - **QIBM_RPG_JAVA_PROPERTIES** allows RPG users to explicitly set the java
    properties used to start the JVM

    This environment variable must be set before any RPG program calls a Java
    method in a job.

    This environment variable has contains Java options, separated and
    terminated by some character that does not appear in any of the option
    strings. Semicolon is usually a good choice.

    Examples:

    1. **Specifying only one option:** If the system's default JDK is 1.3, and you
    want your RPG programs to use JDK 1.4, set environment variable
    QIBM_RPG_JAVA_PROPERTIES to

    ```
    '-Djava.version=1.4;'
    ```

    Note that even with just one option, a terminating character is required. This
    example uses the semicolon.

    2. **Specifying more than one option:** If you also want to set the os400.stdout
    option to a different value than the default, you could set the environment
    variable to the following value:

    ```
    '-Djava.version=1.4!-Dos400.stdout=file:mystdout.txt!'
    ```

This example uses the exclamation mark as the separator/terminator. Note: This support is also available in V5R1 and V5R2 with PTFs. V5R1: SI10069, V5R2: SI10101.

– **QIBM_RPG_JAVA_EXCP_TRACE** allows RPG users to get the exception trace when an RPG call to a Java method ends with an exception

This environment variable can be set, changed, or removed at any time.

If this environment variable contains the value 'Y', then when a Java exception occurs during a Java method call from RPG, or a called Java method throws an exception to its caller, the Java trace for the exception will be printed. By default, it will be printed to the screen, and may not be possible to read. To get it printed to a file, set the Java option os400.stderr. (This would have to be done in a new job; it could be done by setting the QIBM_RPG_JAVA_PROPERTIES environment variable to

```
'-Dos400.stderr=file:stderr.txt;'
```

- **An RPG preprocessor enabling the SQL preprocessor to handle conditional compilation and nested /COPY**

When the RPG compiler is called with a value other than *NONE for parameter PPGENOPT, it will behave as an RPG preprocessor. It will generate a new source file rather than generating a program. The new source file will contain the original source lines that are accepted by the conditional compilation directives such as /DEFINE and /IF. It will also have the source lines from files included by /COPY statements, and optionally it will have the source lines included by /INCLUDE statements. The new source file will have the comments from the original source file if PPGENOPT(*DFT) or PPGENOPT(*NORMVCOMMENT) is specified.When the SQL precompiler is called with a value other than *NONE for new parameter RPGPPOPT, the precompiler will use this RPG preprocessor to handle /COPY, the conditional compilation directives and possibly the /INCLUDE directive. This will allow SQLRPGLE source to have nested /COPY statements, and conditionally used statements.

Table 5. Changed Language Elements Since V5R2

Language Unit	Element	Description
Control specification keywords	CCSID(*GRAPH:parameter | *UCS2:number | *CHAR:*JOBRUN)	Can now take a first parameter of *CHAR, with a second parameter of *JOBRUN, to control how character data is treated at runtime.
Built-in Functions	%DEC(expression {format})	Can now take a parameter of type Date, Time or Timestamp
	%TRIM(expression:expression)	Can now take a second parameter indicating the set of characters to be trimmed
Definition Specification Keywords	OPTIONS(*TRIM)	Indicates that blanks are to be trimmed from passed parameters
Definition Specifications	Length and decimal place entries	The length and number of decimal places can be 63 for packed and zoned fields.

Table 5. Changed Language Elements Since V5R2 (continued)

Input specifications	Length entry	The length can be 32 for packed fields and 63 for zoned fields.
	Decimal place entry	The number of decimal places can be 63 for packed and zoned fields.
Calculation specifications	Length and decimal place entries	The length and number of decimal places can be 63 for packed and zoned fields.
	CHAIN, READ, READE, READP, AND READPE operations	Allow a data structure to be specified in the result field when Factor 2 is the name of an externally-described file.
	CHAIN, READ, READC, READE, READP, READPE, WRITE, UPDATE operations	Allow an externally-described data structure to be specified in the result field when Factor 2 is the name of an externally-described record format.
	SORTA operation	Now has an extended Factor 2, allowing %SUBARR to be specified.

Table 6. New Language Elements Since V5R2

Language Unit	Element	Description
Built-in Functions	%SUBARR(array:starting element {:number of elements})	Returns a section of the array, or allows a section of the array to be modified.

What's New in V5R2?

The following list describes the enhancements made to ILE RPG in V5R2:

- Conversion from character to numeric

  Built-in functions %DEC, %DECH, %INT, %INTH, %UNS, %UNSH and %FLOAT are enhanced to allow character parameters. For example, %DEC('-12345.67' : 7 : 2) returns the numeric value -12345.67.

- Bitwise logical built-in functions

  %BITAND, %BITOR, %BITXOR and %BITNOT allow direct bit manipulation within RPG expressions.

- Complex data structures

  Data structure definition is enhanced to allow arrays of data structures and subfields of data structures defined with LIKEDS that are themselves data structures. This allows the coding of complex structures such as arrays of arrays, or arrays of structures containing subarrays of structures.

  ```
  Example:   family(f).child(i).hobbyInfo.pets(p).type = 'dog';
             family(f).child(i).hobbyInfo.pets(p).name = 'Spot';
  ```

  In addition, data structures can be defined the same as a record format, using the new LIKEREC keyword.

- Enhanced externally-described data structures

Externally-described data structures can hold the programmer's choice of input, output, both, key or all fields. Currently, externally-described data structures can only hold input fields.

- Enhancments to keyed I/O

  Programmers can specify search arguments in keyed Input/Output operations in /FREE calculations in two new ways:

  1. By specifying the search arguments (which can be expressions) in a list.

  2. By specifying a data structure which contains the search arguments.

  ```
  Examples: D custkeyDS   e ds        extname(custfile:*key)
            /free
                CHAIN  (keyA : keyB : key3) custrec;
                CHAIN  %KDS(custkeyDS) custrec;
  ```

- Data-structure result for externally-described files

  A data structure can be specified in the result field when using I/O operations for externally-described files. This was available only for program-described files prior to V5R2. Using a data structure can improve performance if there are many fields in the file.

- UPDATE operation to update only selected fields

  A list of fields to be updated can be specified with an UPDATE operation. Tthis could only be done by using exception output prior to V5R2.

  ```
  Example: update record %fields(salary:status).
  ```

- 31 digit support

  Supports packed and zoned numeric data with up to 31 digits and decimal places. This is the maximum length supported by DDS. Only 30 digits and decimal places were supported prior to V5R2.

- Performance option for FEOD

  The FEOD operation is enhanced by supporting an extender N which indicates that the operation should simply write out the blocked buffers locally, without forcing a costly write to disk.

- Enhanced data area access

  The DTAARA keyword is enhanced to allow the name and library of the data area to be determined at runtime

- New assignment operators

  The new assignment operators +=, -=, *=, /=, **= allow a variable to be modified based on its old value in a more concise manner.

  ```
  Example: totals(current_customer) += count;
  ```

  This statement adds "count" to the value currently in "totals(current_customer)" without having to code "totals(current_customer)" twice.

- IFS source files

  The ILE RPG compiler can compile both main source files and /COPY files from the IFS. The /COPY and /INCLUDE directives are enhanced to support IFS file names.

- Program Call Markup Language (PCML) generation

  The ILE RPG compiler will generate an IFS file containing the PCML, representing the parameters to the program (CRTBNDRPG) or to the exported procedures (CRTRPGMOD).

What's New

Table 7. Changed Language Elements Since V5R1

Language Unit	Element	Description
Built-in functions	%DEC(expression)	Can now take parameters of type character.
	%DECH(expression)	
	%FLOAT(expression)	
	%INT(expression)	
	%INTH(expression)	
	%UNS(expression)	
	%UNSH(expression)	
Definition specification keywords	DTAARA({*VAR:}data-area-name)	The data area name can be a name, a character literal specifying 'LIBRARY/NAME' or a character variable which will determine the actual data area at runtime.
	DIM	Allowed for data structure specifications.
	LIKEDS	Allowed for subfield specifications.
	EXTNAME(filename{:extrecname} {:*ALL|*INPUT|*OUTPUT|*KEY})	The optional "type" parameter controls which type of field is extracted for the externally-described data structure.
Definition Specifications	Length and decimal place entries	The length and number of decimal places can be 31 for packed and zoned fields.
Operation codes	CHAIN, DELETEREADE, READPE, SETGT, SETLL	In free-form operations, Factor 1 can be a list of key values.
	CHAIN, READ, READC, READE, READP, READPE, UPDATE, WRITE	When used with externally-described files or record formats, a data structure may be specified in the result field.
	UPDATE	In free-form calculations, the final argument can contain a list of the fields to be updated.
	FEOD	Operation extender N is allowed. This indicates that the unwritten buffers must be made available to the database, but not necessarily be written to disk.
Calculation specifications	Length and decimal place entries	The length and number of decimal places can be 31 for packed and zoned fields.

Table 8. New Language Elements Since V5R1

Language Unit	Element	Description
Expressions	Assignment Operators += -= *= /= **=	When these assignment operators are used, the target of the operation is also the first operand of the operation.
Control Specification Keywords	DECPREC(30|31)	Controls the precision of decimal intermediate values for presentation, for example, for %EDITC and %EDITW
Definition specification keywords	LIKEREC(intrecname{:*ALL| *INPUT|*OUTPUT|*KEY})	Defines a data structure whose subfields are the same as a record format.

Table 8. New Language Elements Since V5R1 (continued)

Language Unit	Element	Description
Built-in functions	%BITAND(expression : expression)	Returns a result whose bits are on if the corresponding bits of the operands are both on.
	%BITNOT(expression)	Returns a result whose bits are the inverse of the bits in the argument.
	%BITOR(expression : expression)	Returns a result whose bits are on if either of the corresponding bits of the operands is on.
	%BITXOR(expression : expression)	Returns a result whose bits are on if exactly one of the corresponding bits of the operands is on.
	%FIELDS(name{:name...})	Used in free-form ″UPDATE to specify the fields to be updated.
	%KDS(data structure)	Used in free-form keyed operation codes CHAIN, SETLL, SETGT, READE and READPE, to indicate that the keys for the operation are in the data structure.

What's New in V5R1?

The ILE RPG compiler is part of the IBM IBM WebSphere Development Studio for System i product, which now includes the C/C++ and COBOL compilers, and the Application Development ToolSet tools.

The major enhancements to RPG IV since V4R4 are easier interfacing with Java, new built-in functions, free form calculation specifications, control of which file is opened, qualified subfield names, and enhanced error handling.

The following list describes these enhancements:
- Improved support for calls between Java and ILE RPG using the Java Native Interface (JNI):
  – A new data type: Object
  – A new definition specification keyword: CLASS
  – The LIKE definition specification keyword has been extended to support objects.
  – The EXTPROC definition specification keyword has been extended to support Java procedures.
  – New status codes.
- New built-in functions:
  – Functions for converting a number into a duration that can be used in arithmetic expressions: %MSECONDS, %SECONDS, %MINUTES, %HOURS, %DAYS, %MONTHS, and %YEARS.
  – The %DIFF function, for subtracting one date, time, or timestamp value from another.
  – Functions for converting a character string (or date or timestamp) into a date, time, or timestamp: %DATE, %TIME, and %TIMESTAMP.
  – The %SUBDT function, for extracting a subset of a date, time, or timestamp.
  – Functions for allocating or reallocating storage: %ALLOC and %REALLOC.
  – Functions for finding an element in an array: %LOOKUP, %LOOKUPGT, %LOOKUPGE, %LOOKUPLT, and %LOOKUPLE.

- Functions for finding an element in a table: %TLOOKUP, %TLOOKUPGT, %TLOOKUPGE, %TLOOKUPLT, and %TLOOKUPLE.
- Functions for verifying that a string contains only specified characters (or finding the first or last exception to this rule): %CHECK and %CHECKR
- The %XLATE function, for translating a string based on a list of from-characters and to-characters.
- The %OCCUR function, for getting or setting the current occurrence in a multiple-occurrence data structure.
- The %SHTDN function, for determining if the operator has requested shutdown.
- The %SQRT function, for calculating the square root of a number.
- A new free-form syntax for calculation specifications. A block of free-form calculation specifcations is delimited by the compiler directives /FREE and /END-FREE
- You can specify the EXTFILE and EXTMBR keywords on the file specification to control which external file is used when a file is opened.
- Support for qualified names in data structures:
  - A new definition specification keyword: QUALIFIED. This keyword specifies that subfield names will be qualified with the data structure name.
  - A new definition specification keyword: LIKEDS. This keyword specifies that subfields are replicated from another data structure. The subfield names will be qualified with the new data structure name. LIKEDS is allowed for prototyped parameters; it allows the parameter's subfields to be used directly in the called procedure.
  - The INZ definition specification keyword has been extended to allow a data structure to be initialized based on its parent data structure.
- Enhanced error handling:
  - Three new operation codes (MONITOR, ON-ERROR, and ENDMON) allow you to define a group of operations with conditional error handling based on the status code.

Other enhancements have been made to this release as well. These include:
- You can specify parentheses on a procedure call that has no parameters.
- You can specify that a procedure uses ILE C or ILE CL calling conventions, on the EXTPROC definition specification keyword.
- The following /DEFINE names are predefined: *VnRnMn, *ILERPG, *CRTBNDRPG, and *CRTRPGMOD.
- The search string in a %SCAN operation can now be longer than string being searched. (The string will not be found, but this will no longer generate an error condition.)
- The parameter to the DIM, OCCURS, and PERRCD keywords no longer needs to be previously defined.
- The %PADDR built-in function can now take either a prototype name or an entry point name as its argument.
- A new operation code, ELSEIF, combines the ELSE and IF operation codes without requiring an additional ENDIF.
- The DUMP operation code now supports the A extender, which means that a dump is always produced - even if DEBUG(*NO) was specified.

- A new directive, /INCLUDE, is equivalent to /COPY except that /INCLUDE is not expanded by the SQL preprocessor. Included files cannot contain embedded SQL or host variables.
- The OFLIND file-specification keyword can now take any indicator, including a named indicator, as an argument.
- The LICOPT (licensed internal code options) keyword is now available on the CRTRPGMOD and CRTBNDRPG commands.
- The PREFIX file description keyword can now take an uppercase character literal as an argument. The literal can end in a period, which allows the file to be used with qualified subfields.
- The PREFIX definition specification keyword can also take an uppercase character literal as an argument. This literal cannot end in a period.

The following tables summarize the changed and new language elements, based on the part of the language affected.

Table 9. Changed Language Elements Since V4R4

Language Unit	Element	Description
Built-in functions	%CHAR(expression{:format})	The optional second parameter specifies the desired format for a date, time, or timestamp. The result uses the format and separators of the specified format, not the format and separators of the input.
	%PADDR(prototype-name)	This function can now take either a prototype name or an entry point name as its argument.
Definition specification keywords	EXTPROC(*JAVA:class-name:proc-name)	Specifies that a Java method is called.
	EXTPROC(*CL:proc-name)	Specifies a procedure that uses ILE CL conventions for return values.
	EXTPROC(*CWIDEN:proc-name)	Specifies a procedure that uses ILE C conventions with parameter widening.
	EXTPROC(*CNOWIDEN:proc-name)	Specifies a procedure that uses ILE C conventions without parameter widening.
	INZ(*LIKEDS)	Specifies that a data structure defined with the LIKEDS keyword inherits the initialization from its parent data structure.
	LIKE(object-name)	Specifies that an object has the same class as another object.
	PREFIX(character-literal{:number})	Prefixes the subfields with the specified character literal, optionally replacing the specified number of characters.
File specification keywords	OFLIND(name)	This keyword can now take any named indicator as a parameter.
	PREFIX(character-literal{:number})	Prefixes the subfields with the specified character literal, optionally replacing the specified number of characters.
Operation codes	DUMP (A)	This operation code can now take the A extender, which causes a dump to be produced even if DEBUG(*NO) was specified.

What's New

Table 10. New Language Elements Since V4R4

Language Unit	Element	Description
Data types	Object	Used for Java objects
Compiler directives	/FREE ... /END-FREE	The /FREE... /END-FREE compiler directives denote a free-form calculation specifications block.
	/INCLUDE	Equivalent to /COPY, except that it is not expanded by the SQL preprocessor. Can be used to inlcude nested files that are within the copied file. The copied file cannot have embedded SQlL or host variables.
Definition specification keywords	CLASS(*JAVA:class-name)	Specifies the class for an object.
	LIKEDS(dsname)	Specifies that a data structure, prototyped parameter, or return value inherits the subfields of another data strucutre.
	QUALIFIED	Specifies that the subfield names in a data structure are qualified with the data structure name.
File specification keywords	EXTFILE(filename)	Specifies which file is opened. The value can be a literal or a variable. The default file name is the name specified in position 7 of the file specification. The default library is *LIBL.
	EXTMBR(membername)	Specifies which member is opened. The value can be a literal or a variable. The default is *FIRST.

Table 10. New Language Elements Since V4R4 (continued)

Language Unit	Element	Description
Built-in functions	%ALLOC(num)	Allocates the specified amount of storage.
	%CHECK(comparator:base{:start})	Finds the first character in the base string that is not in the comparator.
	%CHECKR(comparator:base{:start})	Finds the last character in the base string that is not in the comparator.
	%DATE(expression{:date-format})	Converts the expression to a date.
	%DAYS(num)	Converts the number to a duration, in days.
	%DIFF(op1:op2:unit)	Calculates the difference (duration) between two date, time, or timestamp values in the specified units.
	%HOURS(num)	Converts the number to a duration, in hours.
	%LOOKUPxx(arg:array{:startindex {:numelems}})	Finds the specified argument, or the specified type of near-match, in the specified array.
	%MINUTES(num)	Converts the number to a duration, in minutes.
	%MONTHS(num)	Converts the number to a duration, in months.
	%MSECONDS(num)	Converts the number to a duration, in microseconds.
	%OCCUR(dsn-name)	Sets or gets the current position of a multiple-occurrence data structure.
	%REALLOC(pointer:number)	Reallocates the specified amount of storage for the specified pointer.
	%SECONDS(num)	Converts the number to a duration, in seconds.
	%SHTDN	Checks if the system operator has requested shutdown.
	%SQRT(numeric-expression)	Calculates the square root of the specified number.
	%SUBDT(value:unit)	Extracts the specified portion of a date, time, or timestamp value.
	%THIS	Returns an Object value that contains a reference to the class instance on whose behalf the native method is being called.
	%TIME(expression{:time-format})	Converts the expression to a time.
	%TIMESTAMP(expression {:*ISO|*ISO0})	Converts the expression to a timestamp.
	%TLOOKUP(arg:search-table {:alt-table})	Finds the specified argument, or the specified type of near-match, in the specified table.
	%XLATE(from:to:string{:startpos})	Translates the specified string, based on the from-string and to-string.
	%YEARS(num)	Converts the number to a duration, in years.

Table 10. New Language Elements Since V4R4 (continued)

Language Unit	Element	Description
Operation codes	MONITOR	Begins a group of operations with conditional error handling.
	ON-ERROR	Performs conditional error handling, based on the status code.
	ENDMON	Ends a group of operations with conditional error handling.
	ELSEIF	Equivalent to an ELSE operation code followed by an IF operation code.
CRTBNDRPG and CRTRPGMOD keywords	LICOPT(options)	Specifies Licensed Internal Code options.

What's New in V4R4?

The major enhancements to RPG IV since V4R2 are the support for running ILE RPG modules safely in a threaded environment, the new 3-digit and 20-digit signed and unsigned integer data types, and support for a new Universal Character Set Version 2 (UCS-2) data type and for conversion between UCS-2 fields and graphic or single-byte character fields.

The following list describes these enhancements:

- Support for calling ILE RPG procedures from a threaded application, such as Domino® or Java™.
  - The new control specification keyword THREAD(*SERIALIZE) identifies modules that are enabled to run in a multithreaded environment. Access to procedures in the module is serialized.
- Support for new 1-byte and 8-byte integer data types: 3I and 20I signed integer, and 3U and 20U unsigned integer
  - These new integer data types provide you with a greater range of integer values and can also improve performance of integer computations, taking full advantage of the 64-bit AS/400 RISC processor.
  - The new 3U type allows you to more easily communicate with ILE C procedures that have single-byte character (char) return types and parameters passed by value.
  - The new INTPREC control specification keyword allows you to specify 20-digit precision for intermediate values of integer and unsigned binary arithmetic operations in expressions.
  - Built-in functions %DIV and %REM have been added to support integer division and remainder operations.
- Support for new Universal Character Set Version 2 (UCS-2) or Unicode data type
  - The UCS-2 (Unicode) character set can encode the characters for many written languages. The field is a character field whose characters are two bytes long.
  - By adding support for Unicode, a single application can now be developed for a multinational corporation, minimizing the necessity to perform code page conversion. The use of Unicode permits the processing of characters in multiple scripts without loss of integrity.
  - Support for conversions between UCS-2 fields and graphic or single-byte character fields using the MOVE and MOVEL operations, and the new %UCS2 and %GRAPH built-in functions.

– Support for conversions between UCS-2 fields or graphic fields with different Coded Character Set Identifiers (CCSIDs) using the EVAL, MOVE, and MOVEL operations, and the new %UCS2 built-in function.

Other enhancements have been made to this release as well. These include:

- New parameters for the OPTION control specification keyword and on the create commands:
  - *SRCSTMT allows you to assign statement numbers for debugging from the source IDs and SEU sequence numbers in the compiler listing. (The statement number is used to identify errors in the compiler listing by the debugger, and to identify the statement where a run-time error occurs.) *NOSRCSTMT specifies that statement numbers are associated with the Line Numbers of the listing and the numbers are assigned sequentially.
  - Now you can choose not to generate breakpoints for input and output specifications in the debug view with *NODEBUGIO. If this option is selected, a STEP on a READ statement in the debugger will step to the next calculation, rather than stepping through the input specifications.
- New special words for the INZ definition specification keyword:
  - INZ(*EXTDFT) allows you to use the default values in the DDS for initializing externally described data structure subfields.
  - Character variables initialized by INZ(*USER) are initialized to the name of the current user profile.
- The new %XFOOT built-in function sums all elements of a specified array expression.
- The new EVALR operation code evaluates expressions and assigns the result to a fixed-length character or graphic result. The assignment right-adjusts the data within the result.
- The new FOR operation code performs an iterative loop and allows free-form expressions for the initial, increment, and limit values.
- The new LEAVESR operation code can be used to exit from any point within a subroutine.
- The new *NEXT parameter on the OVERLAY(name:*NEXT) keyword indicates that a subfield overlays another subfield at the next available position.
- The new *START and *END values for the SETLL operation code position to the beginning or end of the file.
- The ability to use hexadecimal literals with integer and unsigned integer fields in initialization and free-form operations, such as EVAL, IF, etc.
- New control specification keyword OPENOPT{(*NOINZOFL | *INZOFL)} to indicate whether the overflow indicators should be reset to *OFF when a file is opened.
- Ability to tolerate pointers in teraspace — a memory model that allows more than 16 megabytes of contiguous storage in one allocation.

The following tables summarize the changed and new language elements, based on the part of the language affected.

What's New

Table 11. Changed Language Elements Since V4R2

Language Unit	Element	Description
Control specification keywords	OPTION(*{NO}SRCSTMT)	*SRCSTMT allows you to request that the compiler use SEU sequence numbers and source IDs when generating statement numbers for debugging. Otherwise, statement numbers are associated with the Line Numbers of the listing and the numbers are assigned sequentially.
	OPTION(*{NO}DEBUGIO)	*{NO}DEBUGIO, determines if breakpoints are generated for input and output specifications.
Definition specification keywords	INZ(*EXTDFT)	All externally described data structure subfields can now be initialized to the default values specified in the DDS.
	INZ(*USER)	Any character field or subfield can be initialized to the name of the current user profile.
	OVERLAY(name:*NEXT)	The special value *NEXT indicates that the subfield is to be positioned at the next available position within the overlayed field.
	OPTIONS(*NOPASS *OMIT *VARSIZE *STRING *RIGHTADJ)	The new OPTIONS(*RIGHTADJ) specified on a value or constant parameter in a function prototype indicates that the character, graphic, or UCS-2 value passed as a parameter is to be right adjusted before being passed on the procedure call.
Definition specification positions 33-39 (To Position/Length)	3 and 20 digits allowed for I and U data types	Added to the list of allowed values for internal data types to support 1-byte and 8-byte integer and unsigned data.
Internal data type	C (UCS-2 fixed or variable-length format)	Added to the list of allowed internal data types on the definition specifications. The UCS-2 (Unicode) character set can encode the characters for many written languages. The field is a character field whose characters are two bytes long.
Data format	C (UCS-2 fixed or variable-length format)	UCS-2 format added to the list of allowed data formats on the input and output specifications for program described files.
Command parameter	OPTION	*NOSRCSTMT, *SRCSTMT, *NODEBUGIO, and *DEBUGIO have been added to the OPTION parameter on the CRTBNDRPG and CRTRPGMOD commands.

Table 12. New Language Elements Since V4R2

Language Unit	Element	Description
Control specification keywords	CCSID(*GRAPH: *IGNORE | *SRC | number)	Sets the default graphic CCSID for the module. This setting is used for literals, compile-time data and program-described input and output fields and definitions. The default is *IGNORE.
	CCSID(*UCS2: number)	Sets the default UCS-2 CCSID for the module. This setting is used for literals, compile-time data and program-described input and output fields and definitions. The default is 13488.
	INTPREC(10 | 20)	Specifies the decimal precision of integer and unsigned intermediate values in binary arithmetic operations in expressions. The default, INTPREC(10), indicates that 10-digit precision is to be used.
	OPENOPT{(*NOINZOFL | *INZOFL)}	Indicates whether the overflow indicators should be reset to *OFF when a file is opened.
	THREAD(*SERIALIZE)	Indicates that the module is enabled to run in a multithreaded environment. Access to the procedures in the module is to be serialized.
Definition specification keywords	CCSID(number | *DFT)	Sets the graphic and UCS-2 CCSID for the definition.
Built-in functions	%DIV(n:m)	Performs integer division on the two operands n and m; the result is the integer portion of n/m. The operands must be numeric values with zero decimal positions.
	%GRAPH(char-expr | graph-expr | UCS2-expr {: ccsid})	Converts to graphic data from single-byte character, graphic, or UCS-2 data.
	%REM(n:m)	Performs the integer remainder operation on two operands n and m; the result is the remainder of n/m. The operands must be numeric values with zero decimal positions.
	%UCS2(char-expr | graph-expr | UCS2-expr {: ccsid})	Converts to UCS-2 data from single-byte character, graphic, or UCS-2 data.
	%XFOOT(array-expr)	Produces the sum of all the elements in the specified numeric array expression.

Table 12. New Language Elements Since V4R2 (continued)

Language Unit	Element	Description
Operation codes	EVALR	Evaluates an assignment statement of the form result=expression. The result will be right-justified.
	FOR	Begins a group of operations and indicates the number of times the group is to be processed. The initial, increment, and limit values can be free-form expressions.
	ENDFOR	ENDFOR ends a group of operations started by a FOR operation.
	LEAVESR	Used to exit from anywhere within a subroutine.

What's New in V4R2?

The major enhancements to RPG IV since V3R7 are the support for variable-length fields, several enhancements relating to indicators, and the ability to specify compile options on the control specifications. These further improve the RPG product for integration with the OS/400 operating system and ILE interlanguage communication.

The following list describes these enhancements:

- Support for variable-length fields

  This enhancement provides full support for variable-length character and graphic fields. Using variable-length fields can simplify many string handling tasks.

- Ability to use your own data structure for INDARA indicators

  Users can now access logical data areas and associate an indicator data structure with each WORKSTN and PRINTER file that uses INDARA, instead of using the *IN array for communicating values to data management.

- Ability to use built-in functions instead of result indicators

  Built-in functions %EOF, %EQUAL, %FOUND, and %OPEN have been added to query the results of input/output operations. Built-in functions %ERROR and %STATUS, and the operation code extender 'E' have been added for error handling.

- Compile options on the control specification

  Compile options, specified through the CRTBNDRPG and CRTRPGMOD commands, can now be specified through the control specification keywords. These compile options will be used on every compile of the program.

In addition, the following new function has been added:

- Support for import and export of procedures and variables with mixed case names
- Ability to dynamically set the DECEDIT value at runtime
- Built-in functions %CHAR and %REPLACE have been added to make string manipulation easier
- New support for externally defined *CMDY, *CDMY, and *LONGJUL date data formats
- An extended range for century date formats

- Ability to define indicator variables
- Ability to specify the current data structure name as the parameter for the OVERLAY keyword
- New status code 115 has been added to indicate variable-length field errors
- Support for application profiling
- Ability to handle packed-decimal data that is not valid when it is retrieved from files using FIXNBR(*INPUTPACKED)
- Ability to specify the BNDDIR command parameter on the CRTRPGMOD command.

The following tables summarize the changed and new language elements, based on the part of the language affected.

Table 13. Changed Language Elements Since V3R7

Language Unit	Element	Description
Control specification keywords	DECEDIT(*JOBRUN | 'value')	The decimal edit value can now be determined dynamically at runtime from the job or system value.
Definition specification keywords	DTAARA {(data_area_name)}	Users can now access logical data areas.
	EXPORT {(external_name)}	The external name of the variable being exported can now be specified as a parameter for this keyword.
	IMPORT {(external_name)}	The external name of the variable being imported can now be specified as a parameter for this keyword.
	OVERLAY(name{:pos})	The name parameter can now be the name of the current data structure.
Extended century format	*CYMD (cyy/mm/dd)	The valid values for the century character 'c' are now: ``` 'c' Years ---------------------- 0 1900-1999 1 2000-2099 . . . . . . 9 2800-2899 ```
Internal data type	N (Indicator format)	Added to the list of allowed internal data types on the definition specifications. Defines character data in the indicator format.
Data format	N (Indicator format)	Indicator format added to the list of allowed data formats on the input and output specifications for program described files.
Data Attribute	*VAR	Added to the list of allowed data attributes on the input and output specifications for program described files. It is used to specify variable-length fields.

Table 13. Changed Language Elements Since V3R7 (continued)

Language Unit	Element	Description
Command parameter	FIXNBR	The *INPUTPACKED parameter has been added to handle packed-decimal data that is not valid.

Table 14. New Language Elements Since V3R7

Language Unit	New	Description
Control specification keywords	ACTGRP(*NEW ｜ *CALLER ｜ 'activation- group-name')	The ACTGRP keyword allows you to specify the activation group the program is associated with when it is called.
	ALWNULL(*NO ｜ *INPUTONLY ｜ *USRCTL)	The ALWNULL keyword specifies how you will use records containing null-capable fields from externally described database files.
	AUT(*LIBRCRTAUT ｜ *ALL ｜ *CHANGE ｜ *USE ｜ *EXCLUDE ｜ 'authorization-list-name')	The AUT keyword specifies the authority given to users who do not have specific authority to the object, who are not on the authorization list, and whose user group has no specific authority to the object.
	BNDDIR('binding -directory-name' {:'binding-directory-name'...})	The BNDDIR keyword specifies the list of binding directories that are used in symbol resolution.
	CVTOPT(*{NO}DATETIME *{NO}GRAPHIC *{NO}VARCHAR *{NO}VARGRAPHIC)	The CVTOPT keyword is used to determine how the ILE RPG compiler handles date, time, timestamp, graphic data types, and variable-length data types that are retrieved from externally described database files.
	DFTACTGRP(*YES ｜ *NO)	The DFTACTGRP keyword specifies the activation group in which the created program will run when it is called.
	ENBPFRCOL(*PEP ｜ *ENTRYEXIT ｜ *FULL)	The ENBPFRCOL keyword specifies whether performance collection is enabled.
	FIXNBR(*{NO}ZONED *{NO}INPUTPACKED)	The FIXNBR keyword specifies whether decimal data that is not valid is fixed by the compiler.
	GENLVL(number)	The GENLVL keyword controls the creation of the object.
	INDENT(*NONE ｜ 'character-value')	The INDENT keyword specifies whether structured operations should be indented in the source listing for enhanced readability.
	LANGID(*JOBRUN ｜ *JOB ｜ 'language-identifier')	The LANGID keyword indicates which language identifier is to be used when the sort sequence is *LANGIDUNQ or *LANGIDSHR.

Table 14. New Language Elements Since V3R7 (continued)

Language Unit	New	Description
	OPTIMIZE(*NONE | *BASIC | *FULL)	The OPTIMIZE keyword specifies the level of optimization, if any, of the object.
	OPTION(*{NO}XREF *{NO}GEN *{NO}SECLVL *{NO}SHOWCPY *{NO}EXPDDS *{NO}EXT *{NO}SHOWSKP)	The OPTION keyword specifies the options to use when the source member is compiled.
	PRFDTA(*NOCOL | *COL)	The PRFDTA keyword specifies whether the collection of profiling data is enabled.
	SRTSEQ(*HEX | *JOB | *JOBRUN | *LANGIDUNQ | *LANGIDSHR | 'sort-table-name')	The SRTSEQ keyword specifies the sort sequence table that is to be used in the ILE RPG source program.
	TEXT(*SRCMBRTXT | *BLANK | 'description')	The TEXT keyword allows you to enter text that briefly describes the object and its function.
	TRUNCNBR(*YES | *NO)	The TRUNCNBR keyword specifies if the truncated value is moved to the result field or if an error is generated when numeric overflow occurs while running the object.
	USRPRF(*USER | *OWNER)	The USRPRF keyword specifies the user profile that will run the created program object.
File Description Specification keywords	INDDS(data_structure_name)	The INDDS keyword lets you associate a data structure name with the INDARA indicators for a workstation or printer file.
Definition specification keywords	VARYING	Defines variable-length fields when specified on character data or graphic data.
Built-in functions	%CHAR(graphic, date, time or timestamp expression)	Returns the value in a character data type.
	%EOF{file name}	Returns '1' if the most recent file input operation or write to a subfile (for a particular file, if specified) ended in an end-of-file or beginning-of-file condition; otherwise, it returns '0'.
	%EQUAL{file name}	Returns '1' if the most recent SETLL (for a particular file, if specified) or LOOKUP operation found an exact match; otherwise, it returns '0'.
	%ERROR	Returns '1' if the most recent operation code with extender 'E' specified resulted in an error; otherwise, it returns '0'.

Table 14. New Language Elements Since V3R7 (continued)

Language Unit	New	Description
	%FOUND{file name}	Returns '1' if the most recent relevant operation (for a particular file, if specified) found a record (CHAIN, DELETE, SETGT, SETLL), an element (LOOKUP), or a match (CHECK, CHECKR and SCAN); otherwise, it returns '0'.
	%OPEN(file name)	Returns '1' if the specified file is open and '0' if the specified file is closed.
	%REPLACE(replacement string: source string {:start position {:source length to replace}})	Returns the string produced by inserting a **replacement string** into a **source string**, starting at the **start position** and replacing the specified number of characters.
	%STATUS{file name}	If no program or file error occurred since the most recent operation code with extender 'E' specified, it returns 0. If an error occurred, it returns the most recent value set for any program or file status. If a file is specified, the value returned is the most recent status for that file.
Operation code Extender	E	Allows for error handling using the %ERROR and %STATUS built-in functions on the CALLP operation and all operations that allow error indicators.
New century formats	*CMDY (cmm/dd/yy)	To be used by the MOVE, MOVEL, and TEST operations.
	*CDMY (cdd/mm/yy)	To be used by the MOVE, MOVEL, and TEST operations.
New 4-digit year format	*LONGJUL (yyyy/ddd)	To be used by the MOVE, MOVEL, and TEST operations.
Command parameters	PRFDTA	The PRFDTA parameter specifies whether the collection of profiling data is enabled.
	BNDDIR	The BNDDIR parameter was previously only allowed on the CRTBNDRPG command and not on the CRTRPGMOD command, now it is allowed on both commands.

What's New in V3R7?

The major enhancements to RPG IV since V3R6 are the new support for database null fields, and the ability to better control the precision of intermediate results in expressions. Other enhancements include the addition of a floating point data type and support for null-terminated strings. These further improve the RPG product for integration with the OS/400 operating system and ILE interlanguage communication. This means greater flexibility for developing applications.

The following is a list of these enhancements including a number of new built-in functions and usability enhancements:

- Support for database null fields

  This enhancement allows users to process database files which contain null-capable fields, by allowing these fields to be tested for null and set to null.

- Expression intermediate result precision

  A new control specification keyword and new operation code extenders on free-form expression specifications allow the user better control over the precision of intermediate results.

- New floating point data type

  The new floating point data type has a much larger range of values than other data types. The addition of this data type will improve integration with the database and improve interlanguage communication in an ILE environment, specifically with the C and C++ languages.

- Support for null terminated strings

  The new support for null terminated strings improves interlanguage communication. It allows users full control over null terminated data by allowing users to define and process null terminated strings, and to conveniently pass character data as parameters to procedures which expect null terminated strings.

- Pointer addition and subtraction

  Free-form expressions have been enhanced to allow adding an offset to a pointer, subtracting an offset from a pointer, and determining the difference between two pointers.

- Support for long names

  Names longer than 10 characters have been added to the RPG language. Anything defined on the definition or procedure specifications can have a long name and these names can be used anywhere where they fit within the bounds of an entry. In addition, names referenced on any free-form specification may be continued over multiple lines.

- New built-in functions

  A number of new built-in functions have been added to the language which improve the following language facilities:

  - editing (%EDITW, %EDITC, %EDITFLT)
  - scanning strings (%SCAN)
  - type conversions (%INT, %FLOAT, %DEC, %UNS)
  - type conversions with half-adjust (%INTH, %DECH, %UNSH)
  - precision of intermediate results for decimal expressions (%DEC)
  - length and decimals of variables and expressions (%LEN, %DECPOS)
  - absolute value (%ABS)
  - set and test null-capable fields (%NULLIND)
  - handle null terminated strings (%STR)

- Conditional compilation

  RPG IV has been extended to support conditional compilation. This support will include the following:

  - defining conditions (/DEFINE, /UNDEFINE),
  - testing conditions (/IF, /ELSEIF, /ELSE, /ENDIF)
  - stop reading current source file (/EOF)

– a new command option (DEFINE) to define up to 32 conditions on the CRTBNDRPG and CRTRPGMOD commands.

- Date enhancements

  Several enhancements have been made to improve date handling operations. The TIME operation code is extended to support Date, Time or Timestamp fields in the result field. Moving dates or times from and to character fields no longer requires separator characters. Moving UDATE and *DATE fields no longer requires a format code to be specified. Date fields can be initialized to the system (*SYS) or job (*JOB) date on the definition specifications.

- Character comparisons with alternate collating sequence

  Specific character variables can be defined so that the alternate collating sequence is not used in comparisons.

- Nested /COPY members

  You can now nest /COPY directives. That is, a /COPY member may contain one (or more) /COPY directives which can contain further /COPY directives and so on.

- Storage management

  You can now use the new storage management operation codes to allocate, reallocate and deallocate storage dynamically.

- Status codes for storage management and float underflow errors.

  Two status codes 425 and 426 have been added to indicate storage management errors. Status code 104 was added to indicate that an intermediate float result is too small.

The following tables summarize the changed and new language elements, based on the part of the language affected.

Table 15. Changed Language Elements Since V3R6

Language Unit	Element	Description
Definition specification keywords	ALIGN	ALIGN can now be used to align float subfields along with the previously supported integer and unsigned alignment.
	OPTIONS(*NOPASS *OMIT *VARSIZE *STRING)	The *STRING option allows you to pass a character value as a null-terminated string.
Record address type	F (Float format)	Added to the list of allowed record address types on the file description specifications. Signals float processing for a program described file.
Internal data type	F (Float format)	Added to the list of allowed internal data types on the definition specifications. Defines a floating point standalone field, parameter, or data structure subfield.
Data format	F (Float format)	Added to the list of allowed data formats on the input and output specifications for program described files.

Table 16. New Language Elements Since V3R6

Language Unit	New	Description
Control specification keywords	COPYNEST('1-2048')	Specifies the maximum depth for nesting of /COPY directives.
	EXPROPTS(*MAXDIGITS | *RESDECPOS)	Expression options for type of precision (default or "Result Decimal Position" precision rules)
	FLTDIV{(*NO | *YES)}	Indicates that all divide operations in expressions are computed in floating point.
Definition specification keywords	ALTSEQ(*NONE)	Forces the normal collating sequence to be used for character comparison even when an alternate collating sequence is specified.
Built-in functions	%ABS	Returns the absolute value of the numeric expression specified as the parameter.
	%DEC & %DECH	Converts the value of the numeric expression to decimal (packed) format with the number of digits and decimal positions specified as parameters. %DECH is the same as %DEC, but with a half adjust applied.
	%DECPOS	Returns the number of decimal positions of the numeric variable or expression. The value returned is a constant, and may be used where a constant is expected.
	%EDITC	This function returns a character result representing the numeric value edited according to the edit code.
	%EDITFLT	Converts the value of the numeric expression to the character external display representation of float.
	%EDITW	This function returns a character result representing the numeric value edited according to the edit word.
	%FLOAT	Converts the value of the numeric expression to float format.
	%INT & %INTH	Converts the value of the numeric expression to integer. Any decimal digits are truncated with %INT and rounded with %INTH.
	%LEN	Returns the number of digits or characters of the variable expression.
	%NULLIND	Used to query or set the null indicator for null-capable fields.
	%SCAN	Returns the first position of the search argument in the source string, or 0 if it was not found.

Table 16. New Language Elements Since V3R6 (continued)

Language Unit	New	Description
	%STR	Used to create or use null-terminated strings, which are very commonly used in C and C++ applications.
	%UNS & %UNSH	Converts the value of the numeric expression to unsigned format. Any decimal digits are truncated with %UNS and rounded with %UNSH.
Operation code Extenders	N	Sets pointer to *NULL after successful DEALLOC
	M	Default precision rules
	R	No intermediate value will have fewer decimal positions than the result ("Result Decimal Position" precision rules)
Operation codes	ALLOC	Used to allocate storage dynamically.
	DEALLOC	Used to deallocate storage dynamically.
	REALLOC	Used to reallocate storage dynamically.

What's New in V3R6/V3R2?

The major enhancement to RPG IV since V3R1 is the ability to code a module with more than one procedure. What does this mean? In a nutshell, it means that you can code an module with one or more prototyped procedures, where the procedures can have return values and run without the use of the RPG cycle.

Writing a module with multiple procedures enhances the kind of applications you can create. Any application consists of a series of logical units that are conceived to accomplish a particular task. In order to develop applications with the greatest flexibility, it is important that each logical unit be as independent as possible. Independent units are:

- Easier to write from the point of view of doing a specific task.
- Less likely to change any data objects other than the ones it is designed to change.
- Easier to debug because the logic and data items are more localized.
- Maintained more readily since it is easier to isolate the part of the application that needs changing.

The main benefit of coding a module with multiple procedures is greater control and better efficiency in coding a modular application. This benefit is realized in several ways. You can now:

- Call procedures and programs by using the same call operation and syntax.
- Define a prototype to provide a check at compile time of the call interface.
- Pass parameters by value or by reference.
- Define a procedure that will return a value and call the procedure within an expression.
- Limit access to data items by defining local definitions of variables.
- Code a module that does not make use of the cycle.
- Call a procedure recursively.

The run-time behavior of the main procedure in a module is the same as that of a V3R1 procedure. The run-time behavior of any subsequent procedures differs somewhat from a V3R1 program, most notably in the areas of procedure end and exception handling. These differences arise because there is no cycle code that is generated for these procedures.

Other enhancements have been made to for this release as well. These include:

- Support for two new integer data types: signed integer (I), and unsigned integer (U)

  The use of the integer data types provides you with a greater range of values than the binary data type. Integer data types can also improve performance of integer computations.

- *CYMD support for the MOVE, MOVEL, and TEST operations

  You can now use the *CYMD date format in certain operations to work with system values that are already in this data format.

- Ability to copyright your programs and modules by using the COPYRIGHT keyword on the control specification

  The copyright information that is specified using this keyword becomes part of the DSPMOD, DSPPGM, or DSPSRVPGM information.

- User control of record blocking using keyword BLOCK

  You can request record blocking of DISK or SEQ files to be done even when SETLL, SETGT, or CHAIN operations are used on the file. You can also request that blocking not be done. Use of blocking in these cases may significantly improve runtime performance.

- Improved PREFIX capability

  Changes to the PREFIX keyword for either file-description and definition specifications allow you to replace characters in the existing field name with the prefix string.

- Status codes for trigger program errors

  Two status codes 1223 and 1224 have been added to indicate trigger program errors.

The following tables summarize the changed and new language elements, based on the part of the language affected.

Table 17. Changed Language Elements Since V3R1

Language Unit	Element	Description
File description specification keywords	PREFIX(prefix_string {:nbr_of_char_ replaced})	Allows prefixing of string to a field name or a partial rename of the field name
Definition specification keywords	CONST{(constant)}	Specifies the value of a named constant, or indicates that a prototyped parameter that is passed by reference has a constant value
	PREFIX(prefix_string {:nbr_of_char_ replaced})	Allows prefixing of string to a field name or a partial rename of the field name
Operation codes	RETURN	Returns control to the caller, and returns a value, if specified

Table 18. New Language Elements Since V3R1

Language Unit	New	Description
Control specification keywords	COPYRIGHT('copyright string')	Allows you to associate copyright information with modules and programs
	EXTBININT{(*NO | *YES)}	Specifies that binary fields in externally-described files be assigned an integer format during program processing
	NOMAIN	Indicates that the module has only subprocedures
File description specification keywords	BLOCK(*YES |*NO)	Allows you to control whether record blocking occurs (assuming other conditions are met)
Definition specification keywords	ALIGN	Specifies whether integer or unsigned fields should be aligned
	EXTPGM(name)	Indicates the external name of the prototyped program
	EXTPROC(name)	Indicates the external name of the prototyped procedure
	OPDESC	Indicates whether operational descriptors are to be passed for the prototyped bound call
	OPTIONS(*NOPASS *OMIT *VARSIZE)	Specifies various options for prototyped parameters
	STATIC	Specifies that the local variable is to use static storage
	VALUE	Specifies that the prototyped parameter is to be passed by value
Built-in functions	%PARMS	Returns the number of parameters passed on a call
Operation codes	CALLP	Calls a prototyped program or procedure
Specification type	Procedure specification	Signals the beginning and end of a subprocedure definition
Definition type	PR	Signals the beginning of a prototype definition
	PI	Signals the beginning of a procedure interface definition
	blank in positions 24-25	Defines a prototyped parameter